MARYLAND DEPARTMENT OF NATURAL RESOURCES

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Maryland Tributary Strategy Patapsco/Back Basin Summary Report for 1985-2003 Data

January 2005

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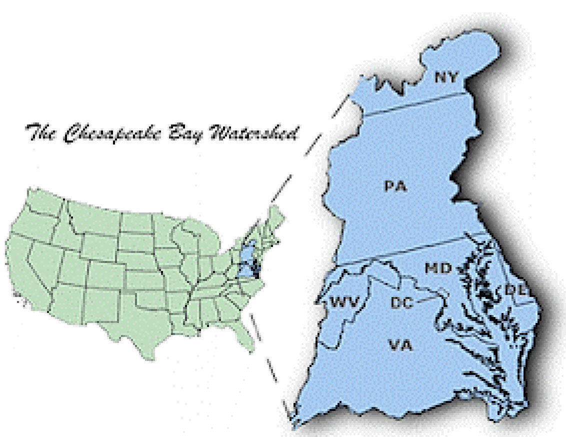
Introduction

The Chesapeake Bay is the largest estuary in North America. A national treasure, the Bay is famous for providing delicious seafood as well as a myriad of recreational and livelihood opportunities, such as boating, fishing, crabbing, swimming, and bird-watching.

By the 1970s, however, our treasured Bay was in serious decline. In 1975, the United States Congress directed the Environmental Protection Agency (EPA) to conduct a comprehensive study of the most important problems affecting the Chesapeake Bay. The findings of this study formed the crux of the first Chesapeake Bay Agreement, signed in 1983 by Maryland, Virginia, Pennsylvania, Washington DC, the Chesapeake Bay Commission and the EPA. Additional scientific information gained from monitoring data and modeling efforts was used to amend that Agreement, resulting in the 2000 Chesapeake Bay Agreement (http://www.chesapeakebay.net/agreement.htm).

Science showed that three of the biggest problems facing the health of the Chesapeake Bay and its tributaries (the rivers and streams that flow into the Bay) are excess nitrogen, phosphorus, and sediments. The nutrients nitrogen and phosphorus fuel excessive algae growth. These algae, as well as suspended sediments, cloud the water and prevent Bay grasses from getting enough light; Bay grasses provide essential habitat for crabs and fish as well as food for waterfowl. When algae blooms die, they decompose using up essential oxygen. This lack of oxygen kills bottom-dwellers such as clams and sometimes fish. Another problem with excess nutrients is that they sometimes favor the growth of harmful algae. Harmful algae can be toxic to aquatic animals and even humans. For more details on the Bay's ecosystem and the problems facing it, see http://www.dnr.state.md.us/Bay/monitoring/mon_mngmt_actions/monitoring_mgmt_actions.html.

Figure PB1



The health and vitality of the Chesapeake Bay is a product of what happens in the watershed, the land area the drains into it. The Chesapeake Bay watershed covers 64,000 square miles, and includes land in six states plus Washington DC (Figure PB1).

To help achieve Maryland's share of the reductions in nitrogen, phosphorus, and sediment to the Bay and its tributaries, a Tributary Strategy Team has been appointed for each of the ten Chesapeake Bay subwatersheds in Maryland:

- Upper Western Shore Basin
- Patapsco/Back Rivers Basin
- Lower Western Shore Basin
- Patuxent River Basin
- Upper Potomac River Basin
- Middle Potomac River Basin
- Lower Potomac River Basin
- Upper Eastern Shore Basin
- Choptank Basin
- Lower Eastern Shore Basin

Each team is comprised of business leaders, farmers, citizens, and state and local government representatives who work together to identify the best ways to reduce nutrient and sediment inputs to the Bay.

This report provides:

- Patapsco/Back Rivers basin characteristics
- Nutrient and sediment loadings to the Patapsco/Back Rivers based on model results (the model is developed using monitoring data)
- Overview of monitoring results
    - links to indepth non-tidal water quality information
    - tidal and non-tidal water quality status and trends (based on monitoring data, i.e., measured concentrations from 1985 to 2003)
    - Bay grasses acreage over time
    - long-term information on benthic (bottom-dwelling) community health
    - information on phytoplankton
    - information on zooplankton
    - nutrient limitation information
- individual wastewater treatment plant outputs

The goal of this report is to show current status of the habitat and water quality (how good or bad it is) and long-term trends (how has water quality and habitat improved or worsened since 1985) provided within the context of information about the basin.

Patapsco/Back River Basin Characteristics

The Patapsco/Back River basin drains 630 square miles of land within Maryland's Western Shore. This area includes all of Baltimore City and portions of Anne Arundel, Baltimore, Carroll, and Howard Counties. The majority of the basin lies in the Piedmont physiographic province, but the immediate area surrounding Baltimore Harbor lies in the Coastal Plain province.

The census population in 2000 for the basin was 1,480,000 people. The City of Baltimore is the basin's largest city with suburban communities extending outward in all directions. Other major population centers in this basin include Ellicott City, Towson, and Glen Burnie.

The Maryland Department of Planning land use categories are defined as follows (Figure PB2):

- urban – includes residential, industrial, institutional (such as schools and churches), mining, and open urban lands (such as golf courses and cemeteries)
- agriculture – includes field, forage, and row and garden croplands; pasturelands; orchards and vineyards; feeding operations; and agricultural building/breeding and training facilities, storage facilities, and built-up farmstead areas
- forest – includes deciduous forest, evergreen forest, mixed forest, and brush
- water – includes rivers, waterways, reservoirs, ponds, and the Bay
- wetlands – includes marshes, swamps, bogs, tidal flats, and wet areas
- barren – includes beaches, bare exposed rock and bare ground

The predominant land use in the basin is classified as urban (55 percent) (Figure PB2). Forested and wetland areas comprise the second largest land use at 24 percent. About a fifth (21 percent) of the basin is devoted to agricultural use.

Nearly 96 percent of the housing in the basin is urban, with most of the remaining housing in rural areas. In conjunction with this large amount of urban housing is a heavy reliance on municipal water and sewage systems. Around 93 percent of the basin's housing relies on a municipal sewage system and 95 percent of the housing uses a public water source. Point sources are a major contributor of nutrient loadings to the Patapsco/Back River. There are six municipal sewage plants in the basin, with Biological Nutrient Removal (BNR) implemented at three of them. BNR is considered advanced wastewater treatment and removes excess nitrogen. BNR implementation is planned for two more facilities by 2010. Appendix A contains graphs of nutrient loads from the basin's major wastewater treatment facilities.

About a fifth of the Patapsco/Back River basin is agricultural land. A series of Best Management Practices (BMPs) have been planned to help reduce non point source nutrient and sediment loads. BMP implementation for shore and soil erosion control, agricultural nutrient management plans, forest buffers, marine pumpout installation, septic connections, and stormwater management are all making good progress toward Tributary Strategy goals. Progress has been slower for other issues, such as stream protection, forest conservation and tree plantings, grassed buffers, animal waste management, runoff control, septic pumping, and urban nutrient management.

The Chesapeake Bay Program model categorizes nutrient and sediment loads from both point sources (end of pipe inputs from wastewater treatment plants and industrial outfalls) and non-point sources. The non-point loads are estimated from a variety of sources including land cover, agriculture records, etc. Generally, the categories in Figures PB4-PB6 include:

- point sources – out of pipe from waste water treatment plants and industrial releases
- non-point sources
    - urban – from industrial, residential, institutional, mining and open urban lands
    - agriculture –from row crop, hay, pasture, manure acres
    - forest –from forested lands
    - mixed open –from non-agricultural grasslands including right-of-ways and some golf courses
    - atmospheric deposition to water – deposited from the atmosphere directly to water

For more detailed information, see the document *Chesapeake Bay Watershed Model Land Use Model Linkages to the Airshed and Watershed Models* at http://www.chesapeakebay.net/pubs/1127.pdf.

As of 2002, the Chesapeake Bay Program Phase 4.3 Model indicated that the most significant contributor of nitrogen in the Patapsco/Back River basin were point sources (75 percent). Figure PB3 shows the location of wastewater treatment plants in the basin and Appendix A shows total nitrogen and total phosphorus loadings from those treatment plants. Other nitrogen sources to this basin were urban sources (19 percent) and agriculture (4 percent) (Figure PB4). For phosphorus, the largest contributor was point sources (51 percent), closely followed by urban sources (41 percent). Agricultural lands contributed 4 percent of phosphorus loadings (Figure PB5). Urban sources were the dominant source of sediments (53 percent) followed by agriculture (32 percent) (Figure PB6).

Figure PB2 –2000 Land Use in the Patapsco/Back River Basin

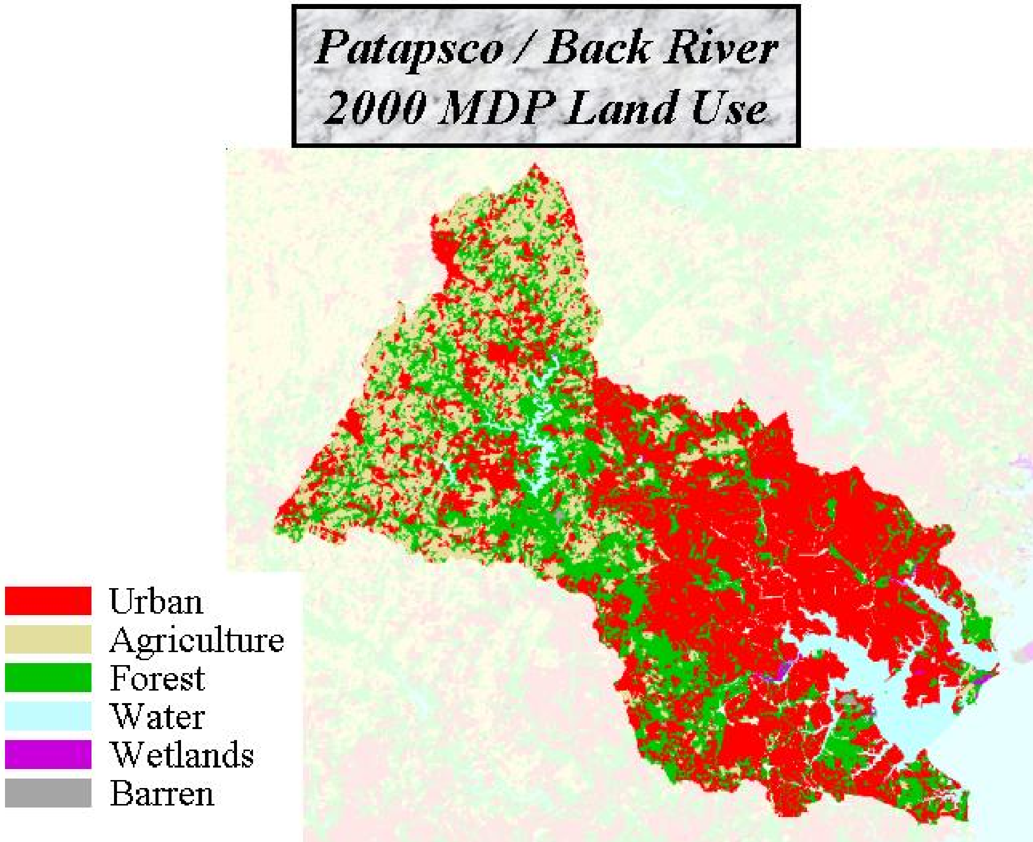


Figure PB3 – Wastewater Treatment Plants in the Patapsco/Back River Basin

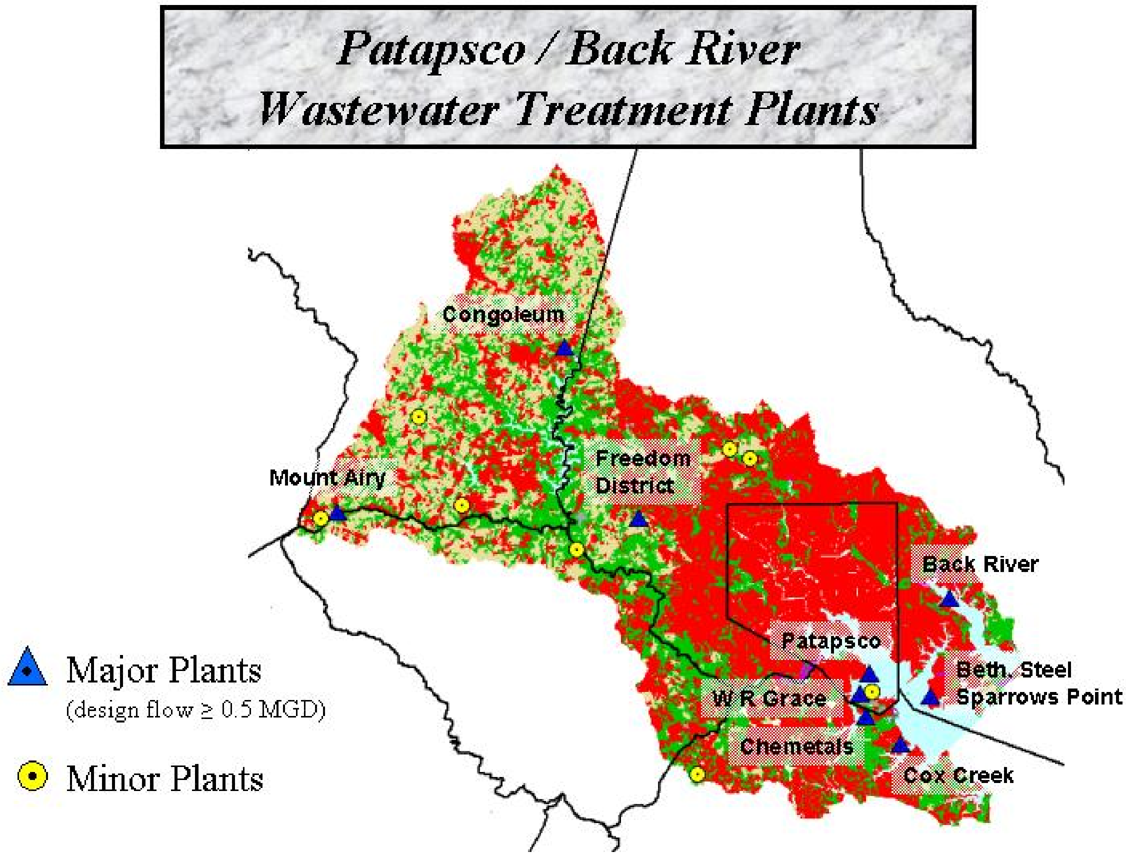
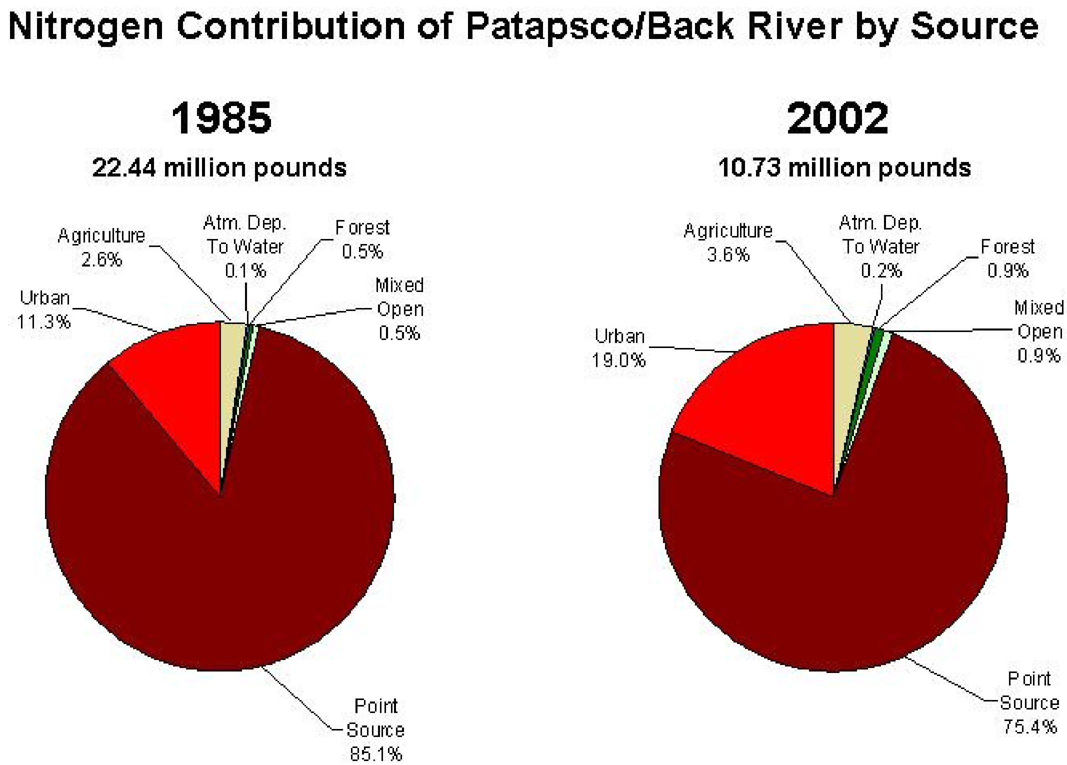


Figure PB4 – 1985 and 2002 Nitrogen Contribution to the Patapsco/Back River by Source.



Source: Chesapeake Bay Program Phase 4.3 Watershed Model

Figure PB5 – 1985 and 2002 Phosphorus contribution to the Patapsco/Back River by Source.

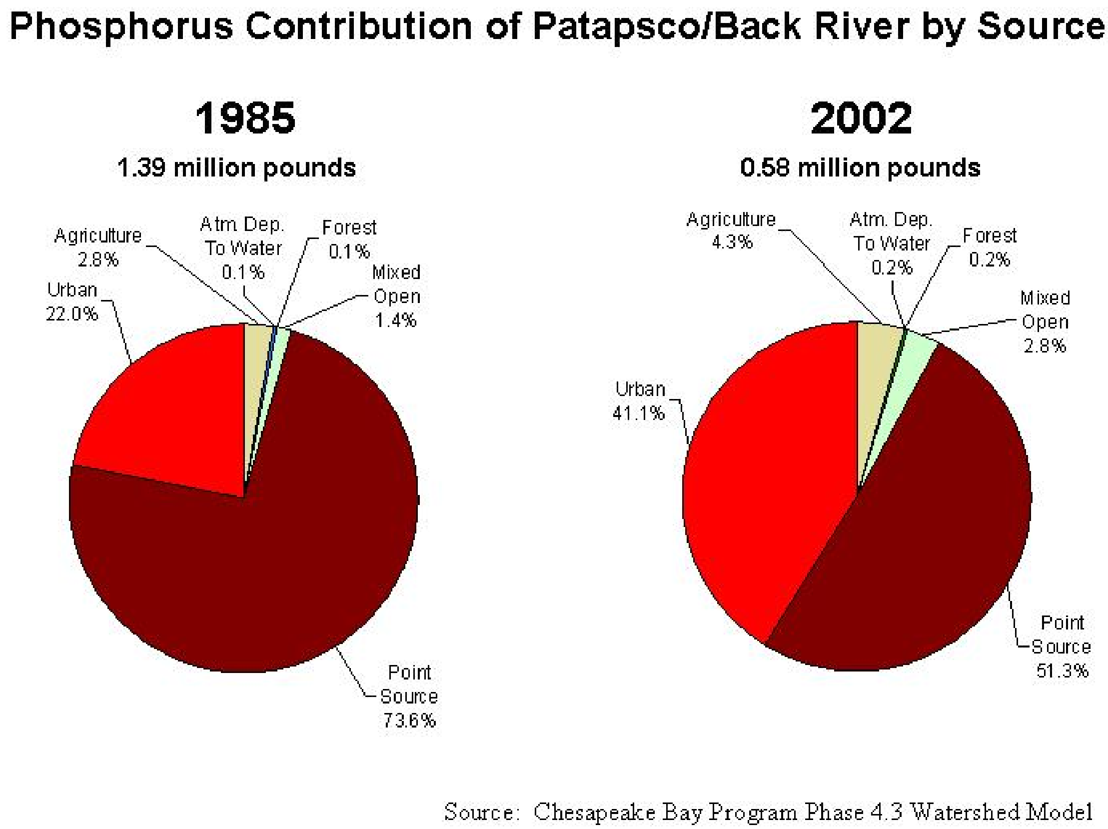
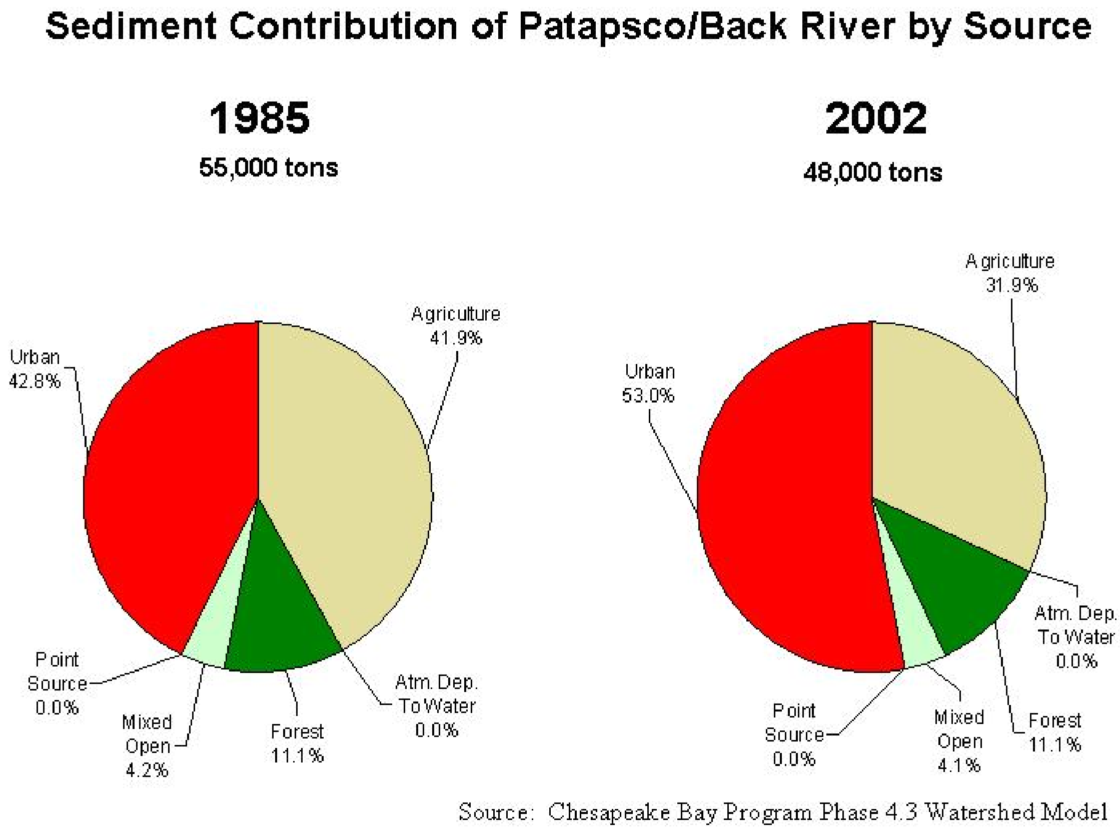


Figure PB6 – 1985 and 2002 Sediment Contribution to the Patapsco/Back River by Source.



Source: Chesapeake Bay Watershed Model

Overview of Monitoring Results

The following sections present results from monitoring various aspects of the ecosystem: water and habitat quality, submerged aquatic vegetation (SAV, i.e., bay grasses), the benthic (bottom-dwelling) community, phytoplankton and zooplankton, and nutrient limitation. Unless otherwise noted, the data are from the State of Maryland's long-term monitoring programs.

Water and Habitat Quality

Non-tidal Water Quality Monitoring Information Sources

Much useful information on non-tidal water quality is available on the Internet. The State of Maryland's Biological Stream Survey (MBSS) basin fact sheets and basin summaries are available at:
http://www.dnr.state.md.us/streams/mbss/mbss_fs_table.html
MBSS also reports stream quality information summarized by county at:
http://www.dnr.state.md.us/streams/mbss/county_pubs.html In addition to these reports and fact sheets, detailed and more recent information and data are also available on the MBSS website: **http://www.dnr.state.md.us/streams/mbss**

Information on the new Watershed Management Tool and stream water quality for Anne Arundel County are available at:
http://www.aacounty.org/LandUse/OECR/index.cfm

Information on Baltimore County water quality monitoring is available at:
http://www.co.ba.md.us/Agencies/environment/

Water quality information collected by Maryland's volunteer Stream Waders is available at: **http://www.dnr.state.md.us/streams/mbss/mbss_volun.html**.

Continuous Water Quality Monitoring Data

Since 2000, continuous monitoring data have been collected in the Baltimore Harbor at a shallow water site near Ft. McHenry as part of a Maryland Department of Natural Resources and National Aquarium in Baltimore partnership. Data on dissolved oxygen, water temperature, salinity, pH, turbidity, and fluorescence (which estimates algae levels) were collected every 15 minutes during the warmer months giving a picture of daily and tidal changes in water quality. View these current data as well as archived data on our Eyes on the Bay website at **www.eyesonthebay.net.** Note that dissolved oxygen levels are low (below 5 mg/L) much of the summer at the Baltimore Harbor station.

Long-term Tidal Water Quality Monitoring

Good water quality is essential to support the animals and plants that live or feed in the Patapsco/Back tributaries. Important water quality parameters are measured at two long-term tidal monitoring stations and five long-term nontidal monitoring stations in the Patapsco/Back basin. Parameters measured include nutrients, water clarity (Secchi depth), dissolved oxygen, total suspended solids, and algal abundance.

Current status is determined based on the most recent three-year period (2001-2003). For dissolved oxygen, the current concentrations are compared to ecologically meaningful thresholds to assign a status of good, fair, or poor. State thresholds have not been established for the other parameters, although a water quality criteria document has been completed by the Chesapeake Bay Program—http://www.chesapeakebay.net/baycriteria.htm—and new water quality criteria (for dissolved oxygen, water clarity, and chlorophyll) are currently being developed by the Maryland Department of the Environment—http://www.mde.state.md.us/ResearchCenter/Data/waterQualityStandards/index.asp. Until the new water quality critieria have been approved, the current data through 2003 are compared to a baseline data set, and assigned a status of good, fair, or poor, which is only a *relative* status compared to the baseline data. Trends are determined using a non-parametric test for trend (the Seasonal Kendall test). For a detailed description of the methods used to determine status and trends, see http://www.dnr.state.md.us/Bay/tribstrat/status_trends_methods.html**.**

Generally water quality is poor in the tidal areas. Patapsco River tidal water quality was poor for five of the six parameters (total nitrogen, total phosphorus, algal abundance, water clarity, and dissolved oxygen). Nitrogen and phosphorus levels were poor at the tidal station at Back River. Non-tidal nutrient concentrations varied. Improving trends were detected at the tidal stations for both nitrogen and phosphorus. Algae levels were poor at both tidal stations, and worsening at the Back River station. Total suspended solids levels were worsening at the Patapsco tidal station. Summer dissolved oxygen status was poor and worsening at the Patapsco River station (depth of 14 meters) but good at the shallower Back River station (2 meters deep). See Figures PB7-PB12.

Figure PB7 – Total Nitrogen Concentrations in the Patapsco/Back River Basin

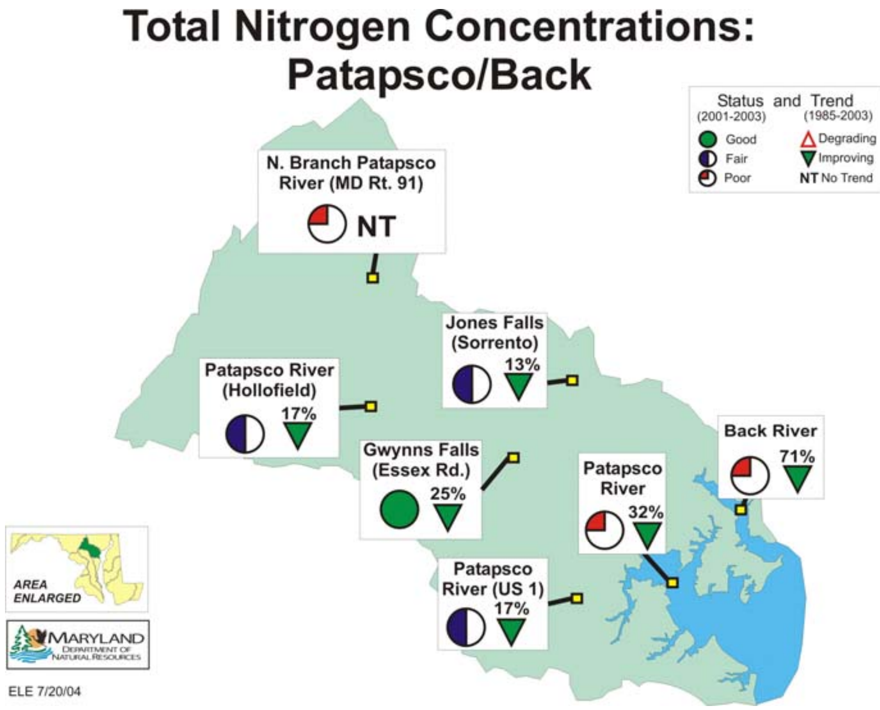


Figure PB8 – Total Phosphorus Concentrations in the Patapsco/Back River Basin

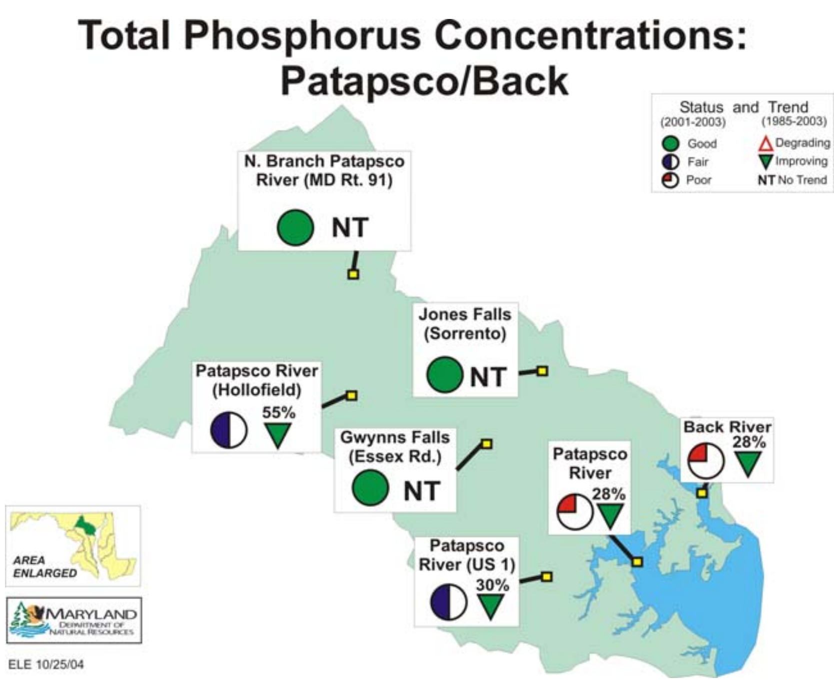


Figure PB9 – Abundance of Algae in the Patapsco/Back River Basin

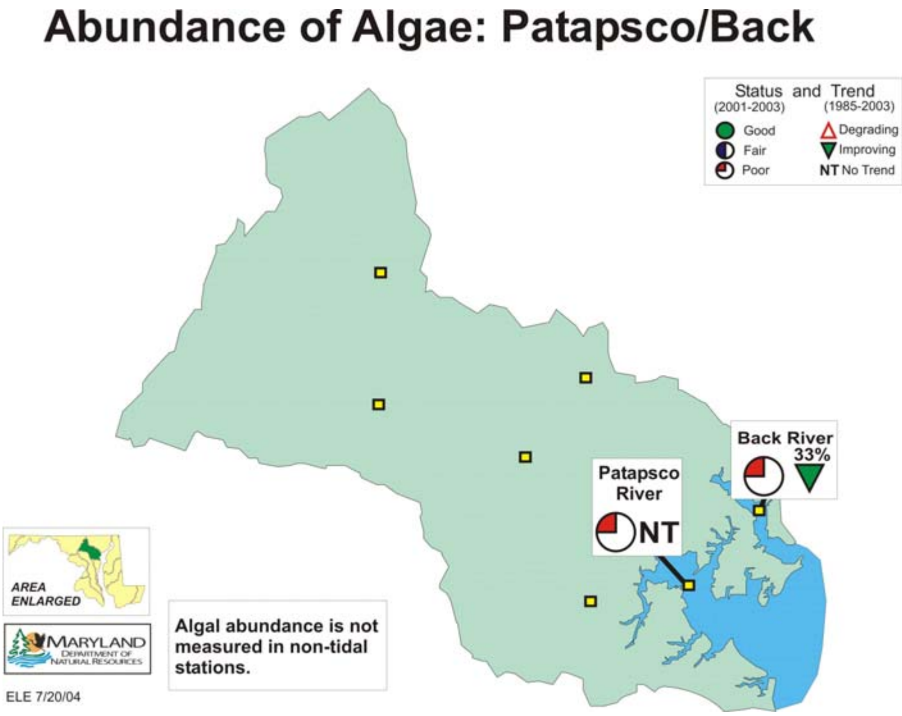


Figure PB10 – Total Suspended Solids in the Patapsco/Back River Basin

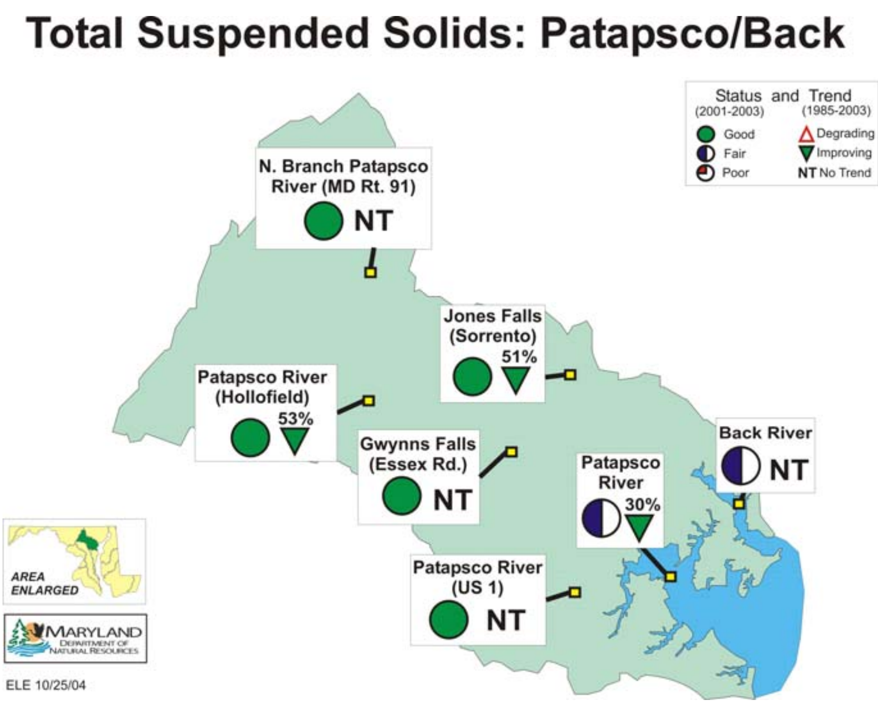


Figure PB11 – Secchi Depth in the Patapsco/Back River Basin

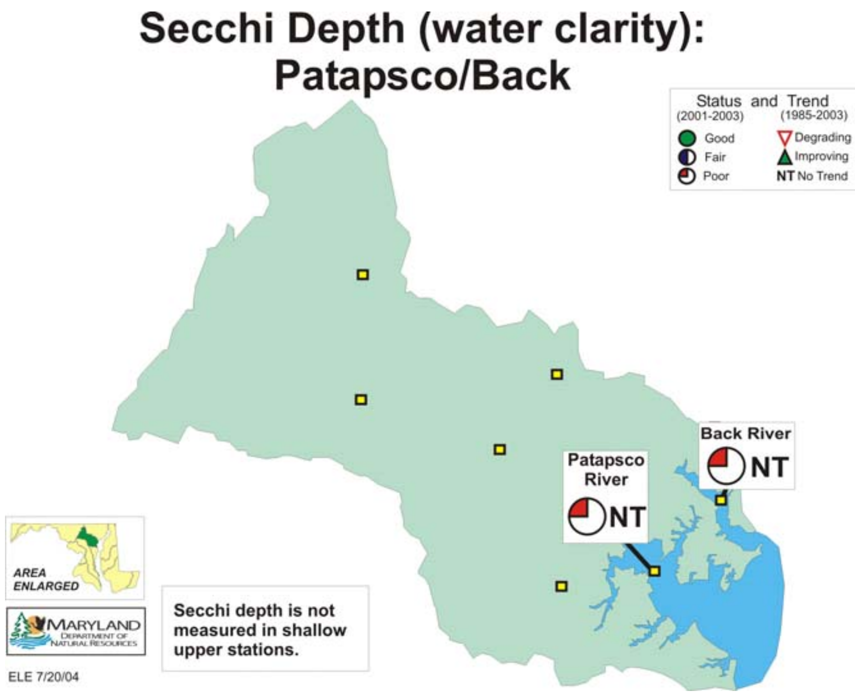
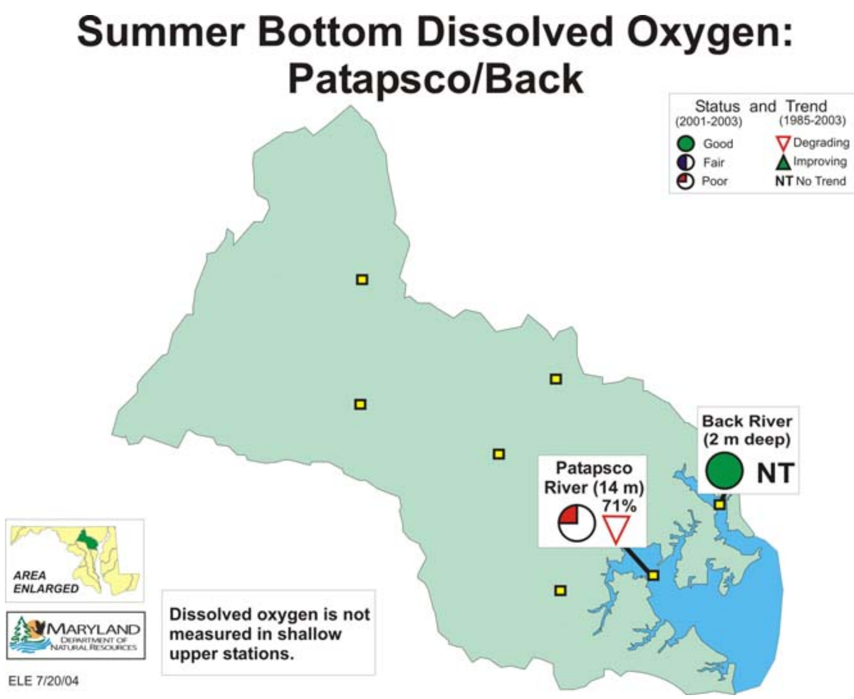


Figure PB12 – Summer Dissolved Oxygen in the Patapsco/Back River Basin



Bay Grasses (Submerged Aquatic Vegetation—SAV)

The well defined linkage between water quality and submerged aquatic vegetation (SAV) distribution and abundance make SAV communities good barometers of the health of estuarine ecosystems. SAV is important not only as an indicator of water quality, but it is also a critical nursery habitat for many estuarine species. Blue crab post-larvae are 30 times more abundant in SAV beds than adjacent unvegetated areas. Similarly, several species of waterfowl depend on SAV as food when they over-winter in the Chesapeake region.

The Chesapeake Bay Program has developed new criteria for determining SAV habitat suitability of an area based on water quality. The APercent Light at Leaf@ habitat requirement assesses the amount of available light reaching the leaf surface of SAV after being attenuated in the water column and by epiphytic growth on the leaves themselves. The document describing this new model is found on the Chesapeake Bay Program website (www.chesapeakebay.net/pubs/sav/index.html). The older AHabitat Requirements@ of five water quality parameters are still used for diagnostic purposes.

In the Back River basin, the Virginia Institute of Marine Science (VIMS) has not recorded SAV since 1984 (www.vims.edu/bio/sav/), and there is no goal for this system (Figure PB13). Also, there is no ground-truthing information available for this area. The water quality data from the monitoring station located between Stansbury Point and Muddy Gut indicates that Back River has borderline algae and phosphorus levels and fails all other habitat requirements (Figure PB14) for SAV growth and survival (Percent light at leaf, light attenuation, and suspended solid concentrations, there is no nitrogen habitat requirement for oligohaline areas like Back River). Surprisingly, wild celery (*Vallisneria americana*) transplants performed in 1999, 2000, 2001 and 2002 in Long Creek (near the launch ramp at Rocky Point Park, Back River Neck area, near the mouth of Back River) have performed very well (www.dnr.state.md.us/Bay/sav/rocky_point.html). In fall of 2003, there was approximately a quarter acre of plants that survived the winter from the 1999 to 2002 plantings. There was evidence of the plants successfully flowering and producing seeds, which will hopefully lead to more SAV recovery in the future.

For the mesohaline Patapsco River, only very small amounts of SAV have been recorded by VIMS (www.vims.edu/bio/sav/), with the highest coverage in 1998 (14.5 acres) (Figure PB13). These beds are exclusively identified in Shallow Creek, near the northern mouth of the Patapsco River. The revised SAVgoal is 298 acres. Ground-truthing has found seven species of SAV in the Patapsco, frequently in beds too small to be mapped by the aerial survey, located in Shallow, Marley, Stony and Rock Creek. In order of occurrence, these species are: Eurasian watermilfoil, horned pondweed, elodea, redhead grass, wild celery, curly pondweed and coontail. Water quality data from the monitoring station located near the Key Bridge and Fort Carroll Island indicates light attenuation fails and all other habitat requirements are borderline to the SAV habitat requirements (Figure PB14).

Additional information on SAV and coverage throughout the Bay is available at: http://www.dnr.state.md.us/Bay/sav/grass_info.html.

Figure PB13 –Bay Grasses (Submerged Aquatic Vegetation) Distribution in the Patapsco/Back Basin.

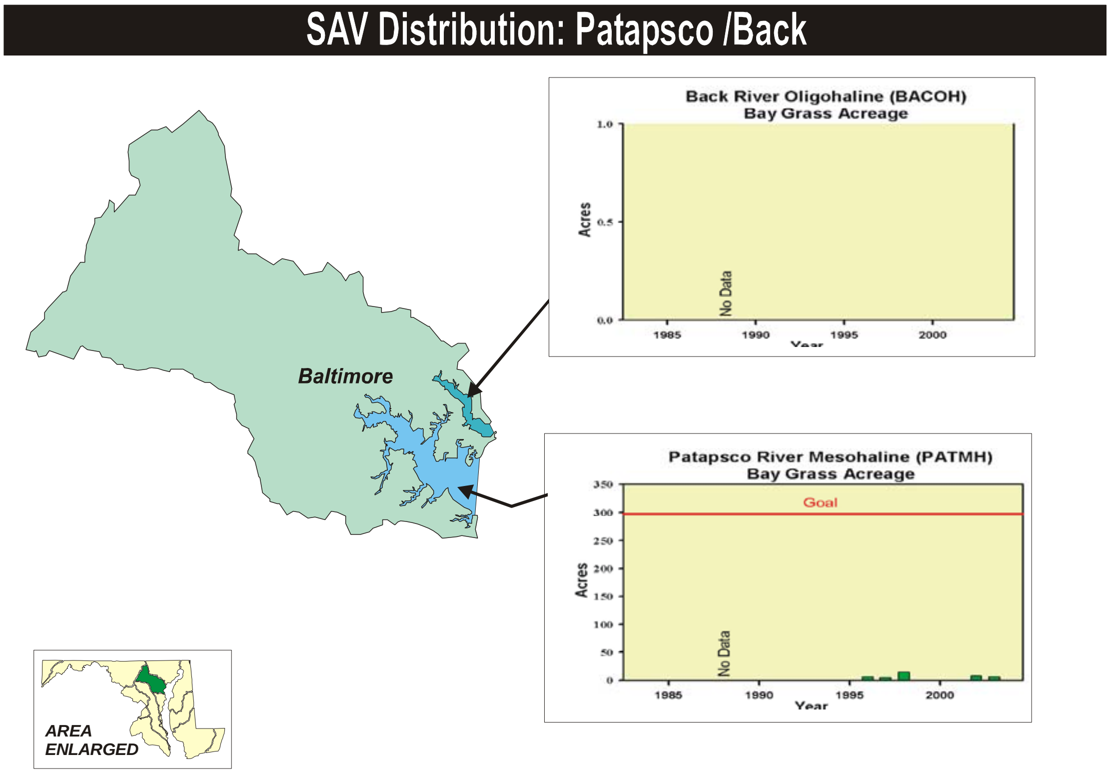
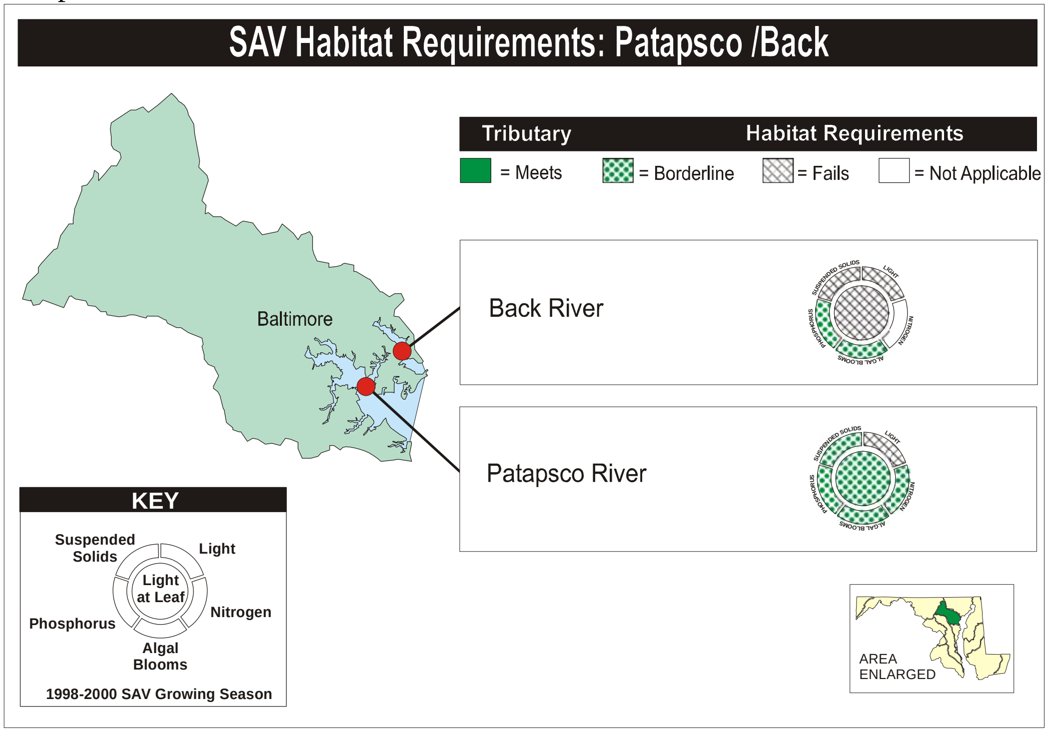


Figure 1: SAV coverage in Patapsco/Back Rivers, 1984 to 2003

Figure PB14 –Bay Grasses (Submerged Aquatic Vegetation) Habitat Requirements in the Patapsco/Back Basin.



Benthic Community

The benthic community forms an integral part of the ecosystem in estuarine systems. For example, small worms and crustaceans are key food items for crabs and demersal fish, such as spot and croaker. Suspension feeders that live in the sediments, such as clams, can be extremely important in removing excess algae from the water column. Benthic macroinvertebrates are reliable and sensitive indicators of estuarine habitat quality.

Benthic community condition in the Patapsco River estuary for the period 1999-2003 was mostly degraded. The probability of observing degraded benthos was 62 percent with 90 percent confidence (Figure PB15). Severely degraded condition occurred in the upper portion of the estuary, above the Francis Scott Key Bridge and at sites in Curtis Creek, Stony Creek, and along the deep channel south of Sparrows Point. These areas are affected by very low dissolved oxygen concentrations and/or toxic contamination. Excess abundance indicating eutrophic conditions was common in the lower portion of the estuary in areas that are not typically affected by hypoxia. In a study conducted by Ranasinghe et al. (1994), benthic community degradation in the Patapsco River was inversely correlated with trace metal concentrations, and in laboratory bioassays sediments from Bear Creek were significantly toxic to the amphipod *Leptocheirus plumulosus* (Scott et al. 1991).

The Back River estuary showed moderately degraded benthic condition with total densities of organisms that were either within the good range or in excess of reference conditions, in agreement with pollution related to excess algal growth and high particulate organic deposition. In contrast to the Patapsco River, dissolved oxygen conditions in the Back River are usually good.

Fixed long-term monitoring stations in the Patapsco/Back River basin indicated degraded to severely degraded benthic community condition (Figure PB16), except for Station 23, which showed improvements in the last three years. No trends in the B-IBI were detected in 2003.

Figure PB15. Total number of sites, degraded sites, and probabilities (90 percent confidence limits) of observing degraded benthos, non-degraded benthos, or benthos of intermediate condition (indeterminate for low salinity habitats) for the Patapsco/Back River Basin, 1999-2003.

Segment	Tributary	Total No. Sites	No. Deg. Sites	P Deg.	P Non-deg.	P Interm.
PATMH	Patapsco	48	30	61.5 (50.4–72.7)	15.4 (7.1–23.6)	26.9 (16.8–37.1)
BACOH	Back	5	3	55.6 (28.2–82.9)	22.2 (0–45.1)	44.4 (17.1–71.8)

Figure PB16. Trends in benthic community condition for Patapsco and Back River fixed stations, 1985-2003. Trends were identified using the van Belle and Hughes (1984) procedure. Current mean B-IBI and condition based on 2001-2003 values. Initial mean B-IBI and condition based on 1985-1987 values for Sta. 22 and 23, 1989-1991 values for Sta. 201 and 202, and 1995-1997 values for Sta. 203. NS: not significant.

Station[1]	Trend Significance	Median Slope (B-IBI units/yr)	Current Condition (2001-2003)	Initial Condition (See heading)
22, Middle Branch	NS	0.00	1.76 (Severely Degraded)	2.08 (Degraded)
23, Patapsco River	NS	0.00	3.00 (Meets Goal)	2.49 (Degraded)
201, Bear Creek	NS	0.00	1.49 (Severely Degraded)	1.10 (Severely Degr.)
202, Curtis Bay	NS	0.00	1.89 (Severely Degraded)	1.40 (Severely Degr.)
203, Back River	NS	0.02	2.07 (Degraded)	2.08 (Degraded)

[1]Sta. 22, low mesohaline habitat, 39.254940 lat., 76.587354 long.
Sta. 23, low mesohaline habitat, 39.208275 lat., 76.523352 long.
Sta. 201, low mesohaline habitat, 39.234275 lat., 76.497184 long.
Sta. 202, low mesohaline habitat, 39.217940 lat., 76.563853 long.
Sta. 203, oligohaline habitat, 39.275107 lat., 76.446015 long.

For information on benthic community health throughout the Bay, see the 2004 Long-term Benthic Level One Report ("Comprehensive Report") at http://www.esm.versar.com/Vcb/Benthos/referenc.htm.

Phytoplankton

Phytoplankton (generally algae) are the primary producers in the Bay, and many species travel up the food chain to fish, either directly or through zooplankton. However, too much phytoplankton or the wrong kinds degrade the Bay. Too much phytoplankton can shade out bay grasses, and can cause low dissolved oxygen levels at night and when the cells die off. The "wrong kinds" of phytoplankton include cyanobacteria (bluegreens) and some pigmented dinoflagellates. Cyanobacteria are generally smaller cells and not as nutritious and palatable to zooplankton as are the cryptomonads, diatoms, and dinoflagellates. Although many types of dinoflagellates provide a good food source, some of the pigmented dinoflagellates can release toxins and cause red or mahogany tides and fish kills.

The phytoplankton monitoring program samples 13 stations in the Maryland portion of the Bay including one station in the Patapsco River—the same site as the water quality monitoring station. The phytoplankton index of biotic integrity showed that station to have a poor phytoplankton community in spring and summer 2003.

With respect to harmful algae, a mahogany tide (*Prorocentrum minimum* dinoflagellate bloom) occurred in the Patapsco River in December 2004. See information on harmful algae blooms in Maryland at http://www.dnr.state.md.us/Bay/hab/index.html.

Zooplankton

The main types of zooplankton include copepods, rotifers, and cladocerans. Copepods are considered excellent fish food, and thus high biomass and abundances of those animals are good. The zooplankton program has been discontinued due to lack of funds, but information through 2000 is included here. The zooplankton program will be reinstated during 2005.

There were very few significant trends in the microzooplankton data from 1985 to 2000. Annually, there was an improvement in copepod nauplii biomass. Seasonally, summer ciliate biomass improved as well. Ciliates and copepod nauplii are considered good quality fish food.

A number of improving trends were recorded in the mesozooplankton data from 1985 to 2000. Improvements were observed some seasons for mesozooplankton biomass, total mesozooplankton abundance, abundance of the adult copepod species *Eurytemora affinis* and *Acartia tonsa*.

Finfish

Popular game fish in the upper Patapsco River include rainbow trout (a put-and-take fishery) and smallmouth bass. Rock bass, striped bass, redbreast sunfish, hog suckers and white suckers can also be found throughout the river. Historically, the Patapsco River supported spawning runs of anadromous fish such as yellow and white perch, American and hickory shad, alewife and blueback herring as well as the catadromous American eel. Anadromous fish must swim upstream to spawn, and catadromous species swim downstream to spawn. Dams built over the last 150 years on the Patapsco River blocked large areas of spawning habitat. Beginning in the 1990s, much habitat has been restored by building fish ladders into the Bloede, Simpkins and Daniels Dams and by providing breaching with streambank stabilization at Union Dam. Gizzard shad, hickory shad, American shad, river herring, striped bass and white perch migrate up the Patapsco River during early spring. Many minnow species in the Patapsco provide food for smallmouth bass, trout and sunfishes. For information on recreational fisheries in the Patapsco River, see **http://www.dnr.state.md.us/fisheries/recreational/fwhotpatapscoriver.html**.

Nutrient Limitation

Like all plants, phytoplankton need nitrogen, phosphorus, light, and suitable water temperatures to grow. If light is adequate and the water temperature is appropriate, phytoplankton will continue to grow as long as nutrients are available. If nutrients are limited, then the ratio of nitrogen to phosphorus affects phytoplankton growth. Phytoplankton generally use nitrogen and phosphorus at a ratio of 16:1, that is, 16 times as much nitrogen is needed as phosphorus. If one of the nutrients is not available in the adequate quantity, phytoplankton growth is limited by that nutrient. If both nutrients are available in excess, then the system is nutrient saturated.

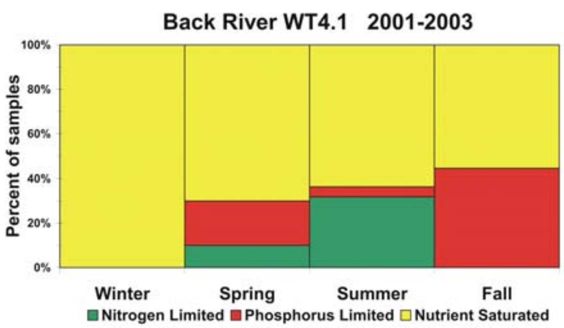
Nitrogen limitation occurs when there is insufficient nitrogen, i.e., there is excess phosphorus. Nitrogen limitation often happens in the summer and fall after stormwater flows are lower (so less nitrogen is being added to the water) and some of the nitrogen has already been used up by phytoplankton growth during the spring. If an area is nitrogen limited, then adding nitrogen will increase phytoplankton growth.

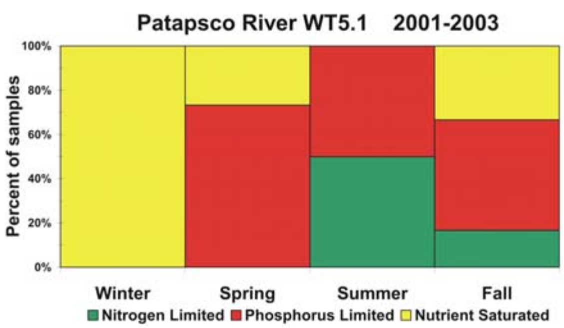
Phosphorus limitation occurs when there is insufficient phosphorus, i.e., there is excess nitrogen. If an area is phosphorus limited, then adding phosphorus will increase phytoplankton growth. Phosphorus limitation occurs in some locations in the spring when large amounts of nitrogen are available to the estuary from stormwater flow.

If an area is light or temperature limited, and both nitrogen and phosphorus are available in excess, then a situation of nutrient saturation occurs. In this case, if phytoplankton are exposed to appropriate water temperatures and sufficient light, they will grow. If an area is both nitrogen and phosphorus limited, then both nitrogen and phosphorus must be added to increase algal growth. Light or temperature limitation occurs more frequently in upstream tidal fresh areas and turbidity maximum zones (light-limited because of higher turbidity) or in winter (inadequate light and temperature for some types of phytoplankton).

Managers can use these predictions based on monitoring information to assess what management approach will be the most effective for controlling excess phytoplankton growth. If an area is phosphorus limited, then reducing phosphorus will bring the most immediate reductions in phytoplankton grown. However, if nitrogen levels are not also reduced, the excess nitrogen that goes unused can be exported downstream. This excess nitrogen may reach an area that is nitrogen limited, fueling phytoplankton growth in that downstream area. When used along with other information available from the water quality and watershed management programs, nutrient limitation predictions form a valuable tool allowing managers to make more cost-effective management decisions.

The nutrient limitation models were used to predict nutrient limitation for the stations in the Patapsco and the Back Rivers. Results are summarized graphically for the most recent three-year period (2001-2003) by season: winter (December-February), spring (March-May), summer (July-September) and fall (October-November). For a text description of the information presented here graphically, see Appendix C.

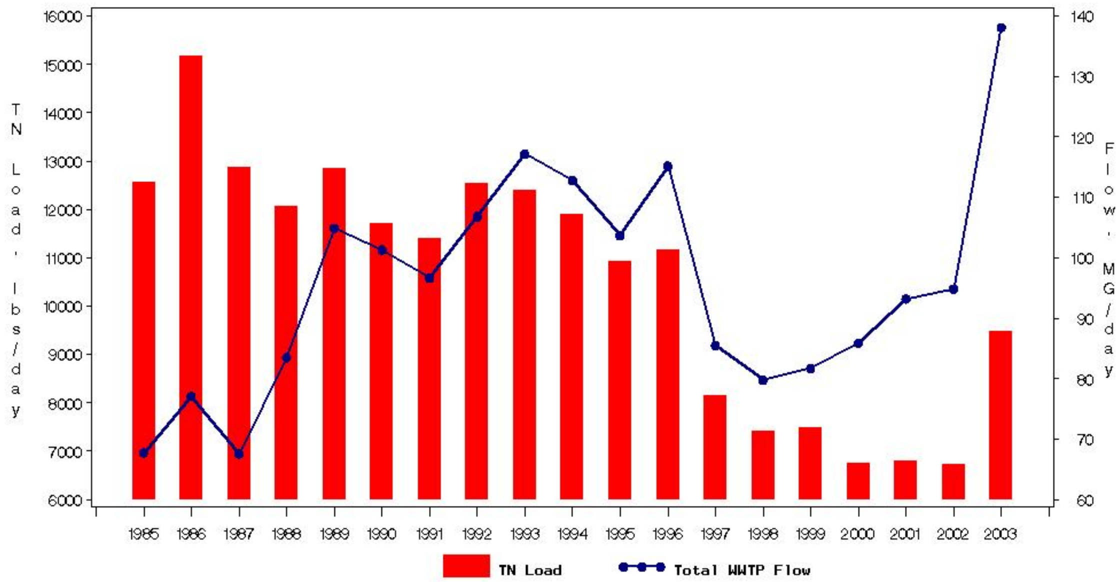




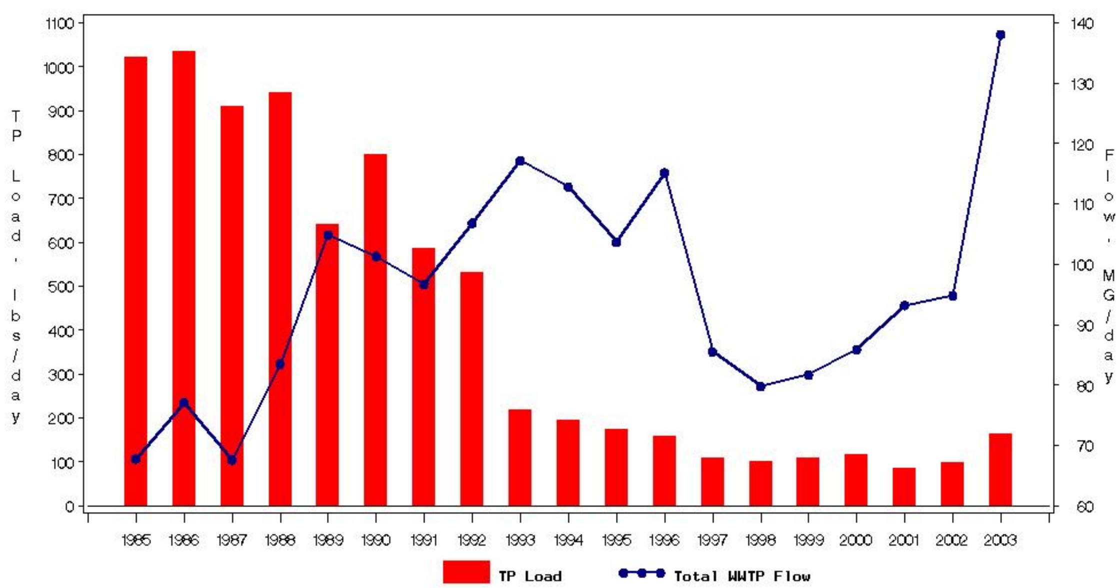
Appendix A – Nutrient Loadings from Major Wastewater Treatment Facilities in the Patapsco/Back River Basin

Annual means of daily wastewater treatment plant loads (red bars) are shown with daily wastewater treatment plant flows (blue line) based on Maryland Department of Environment data for 1985 to 2003. Note that the scale varies for each graph. These data will be made available on the Chesapeake Information Management System (CIMS) database at **http://www.chesapeakebay.net/data/index.htm**.

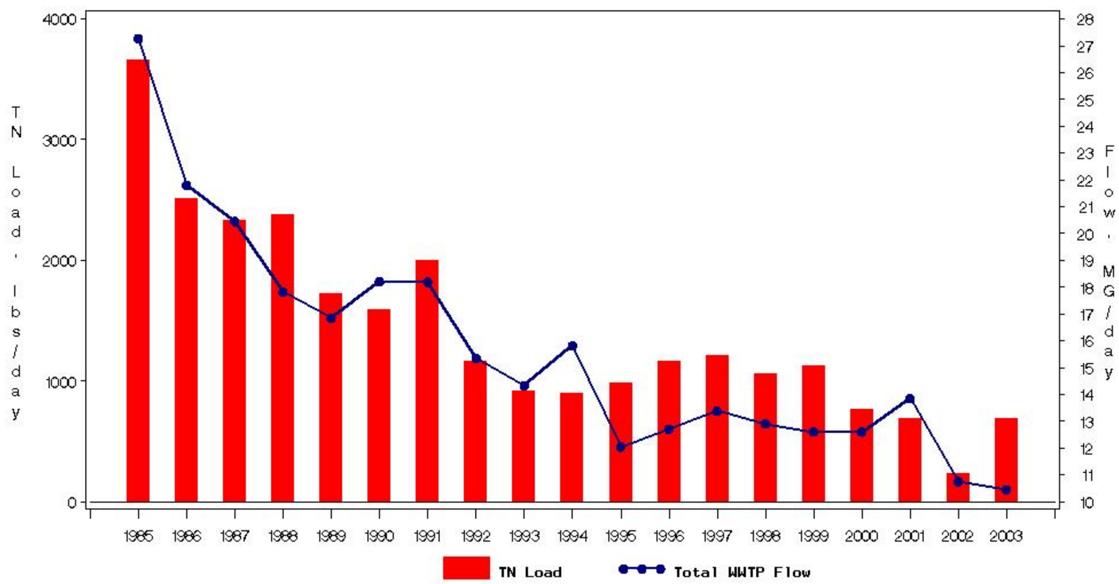
BACK RIVER Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



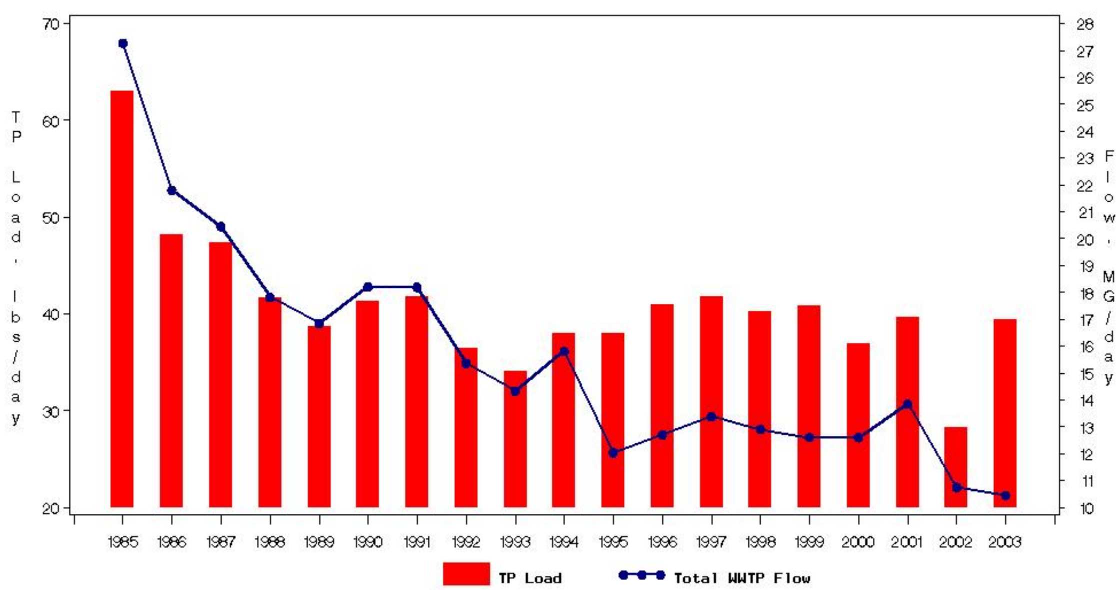
BACK RIVER Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



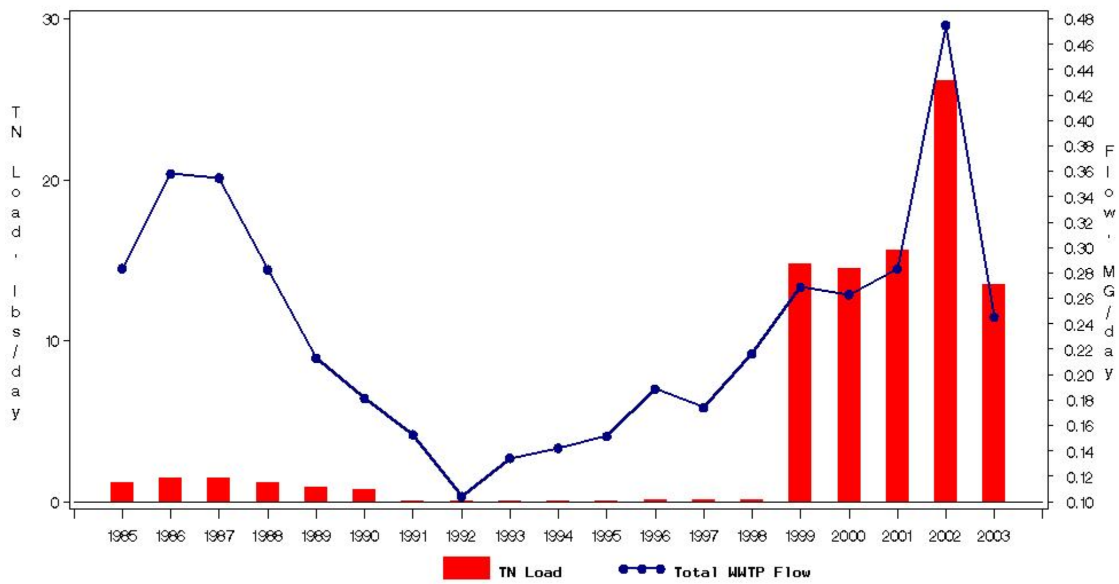
BETHLEHEM STEEL Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



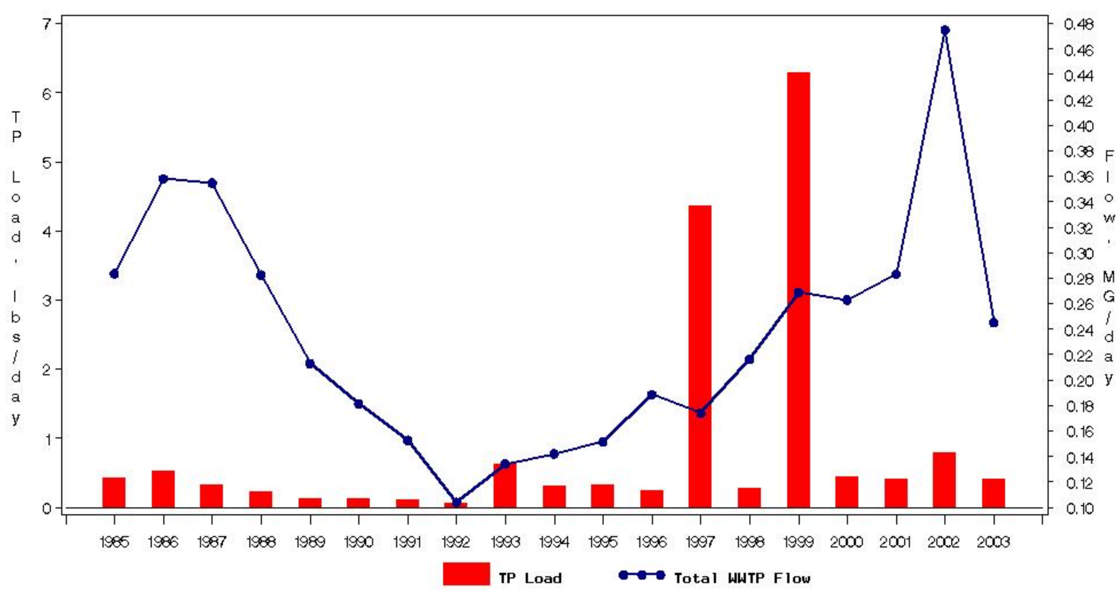
BETHLEHEM STEEL Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow

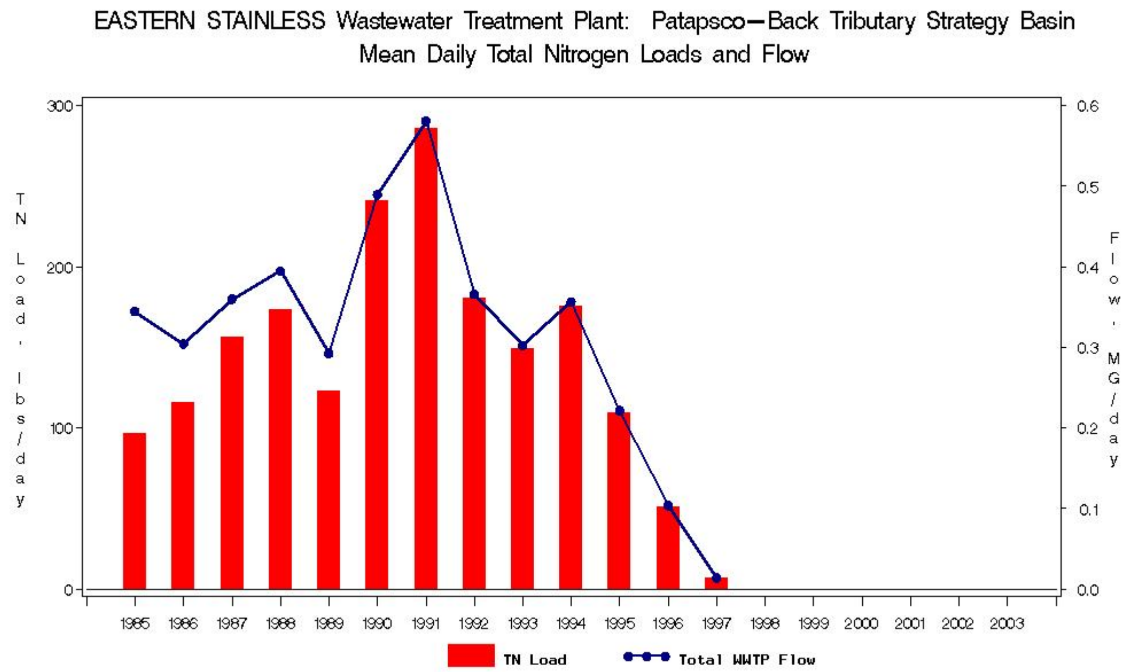


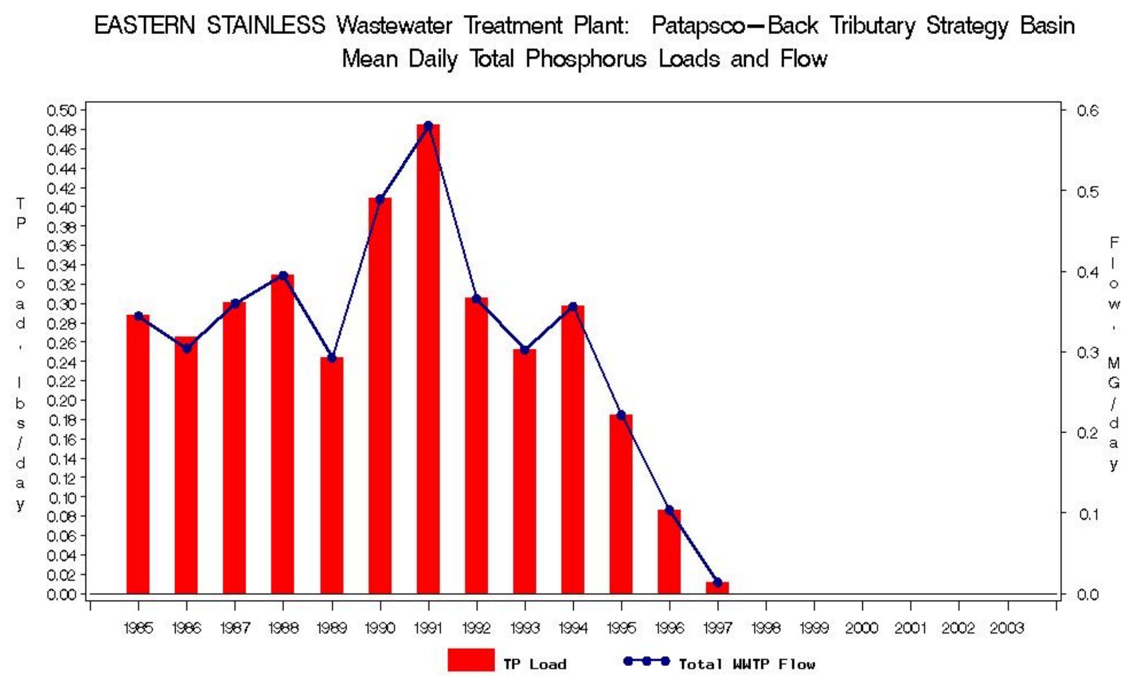
CONGOLEUM Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



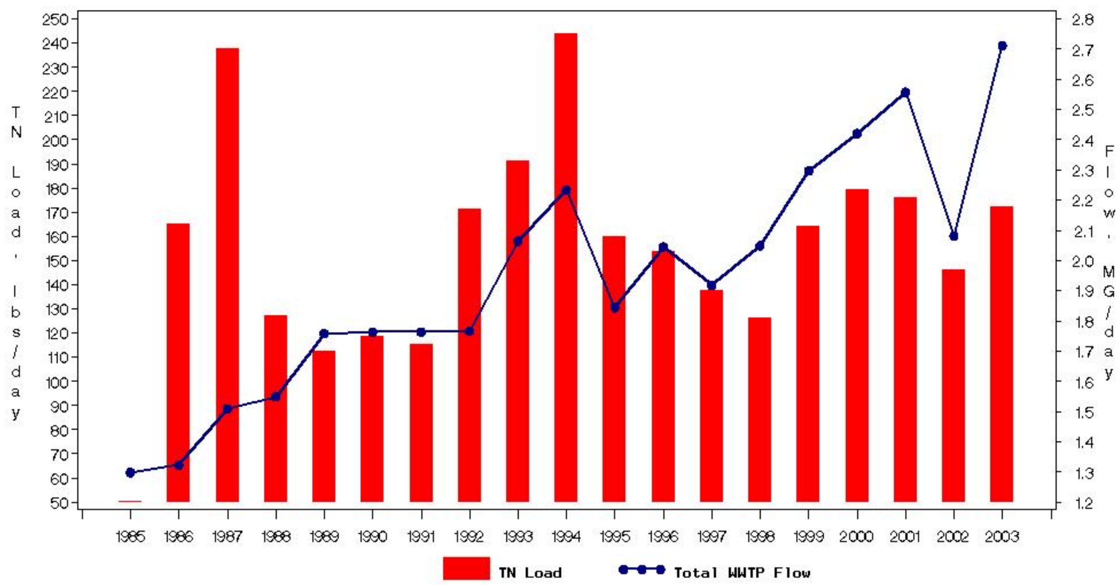
CONGOLEUM Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



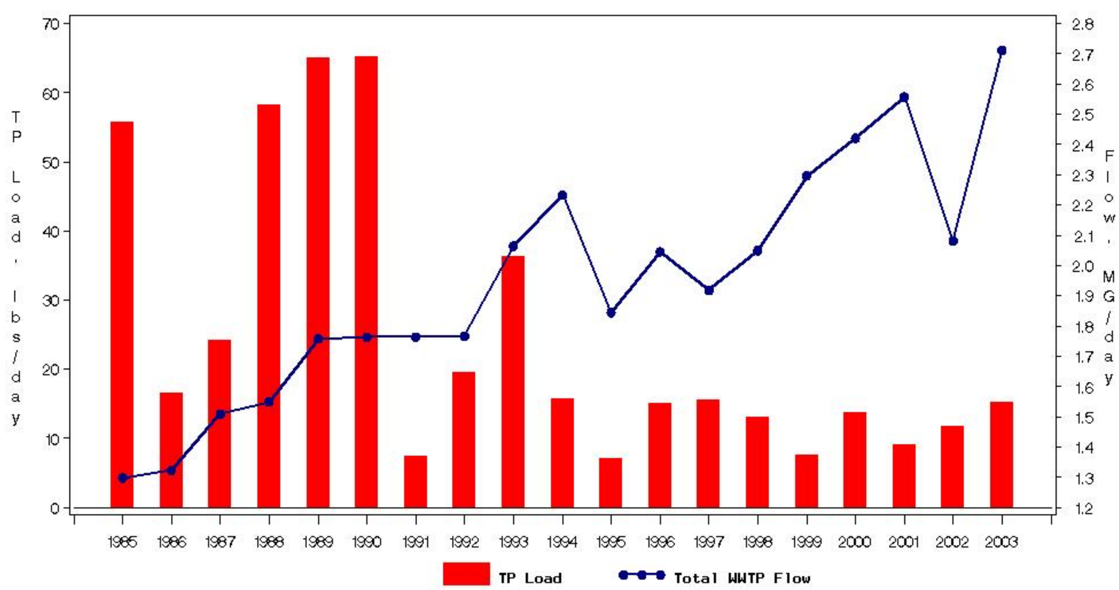

EASTERN STAINLESS Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TN Load
Total WWTP Flow


EASTERN STAINLESS Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TP Load
Total WWTP Flow

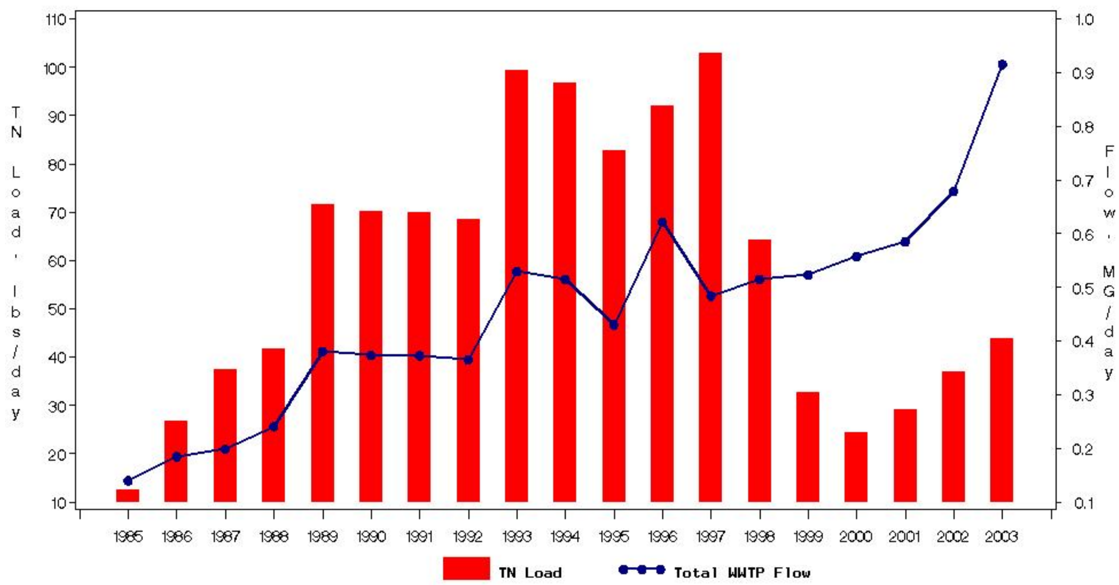
FREEDOM DISTRICT Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



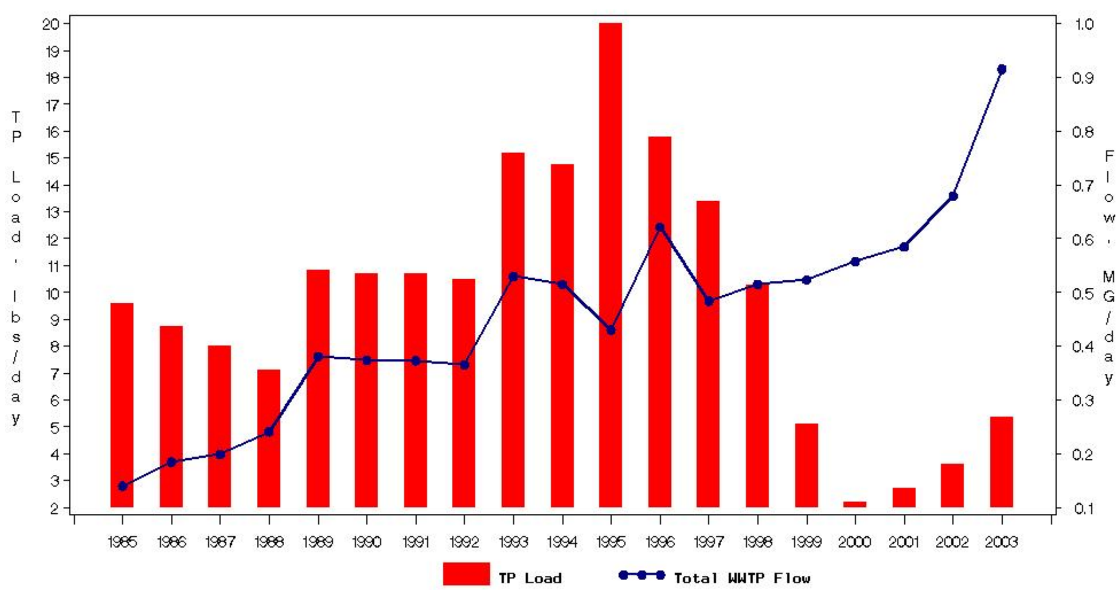
FREEDOM DISTRICT Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



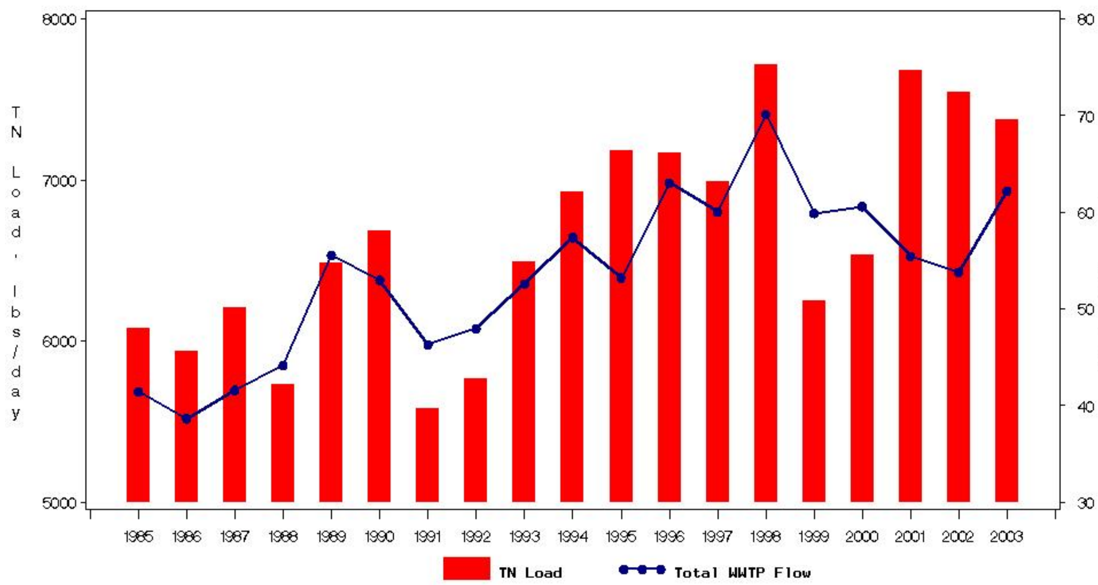
MOUNT AIRY Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



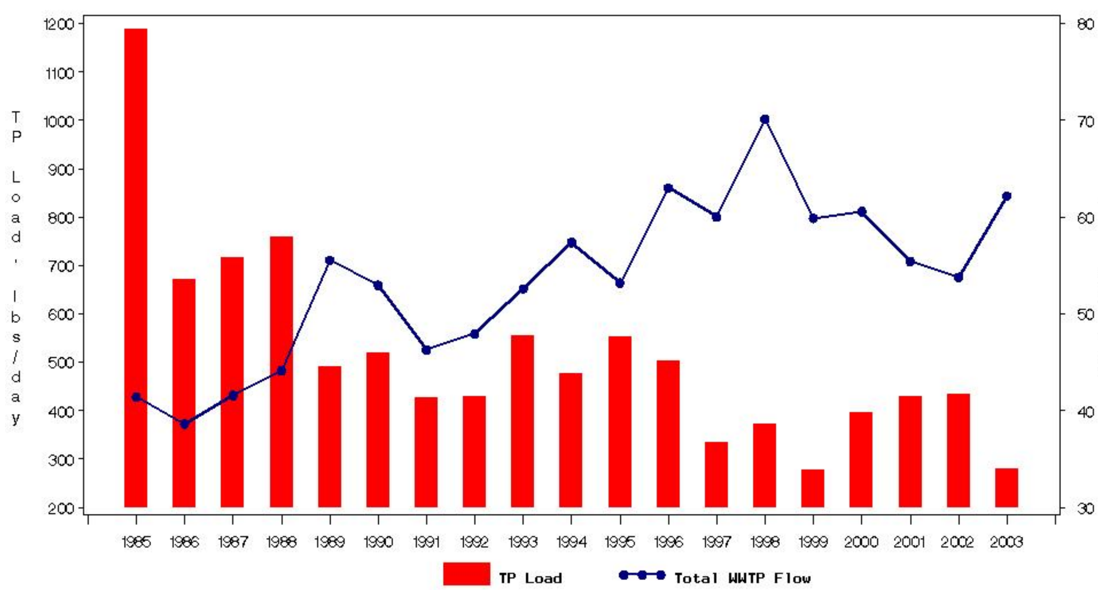
MOUNT AIRY Wastewater Treatment Plant: Patapsco–Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



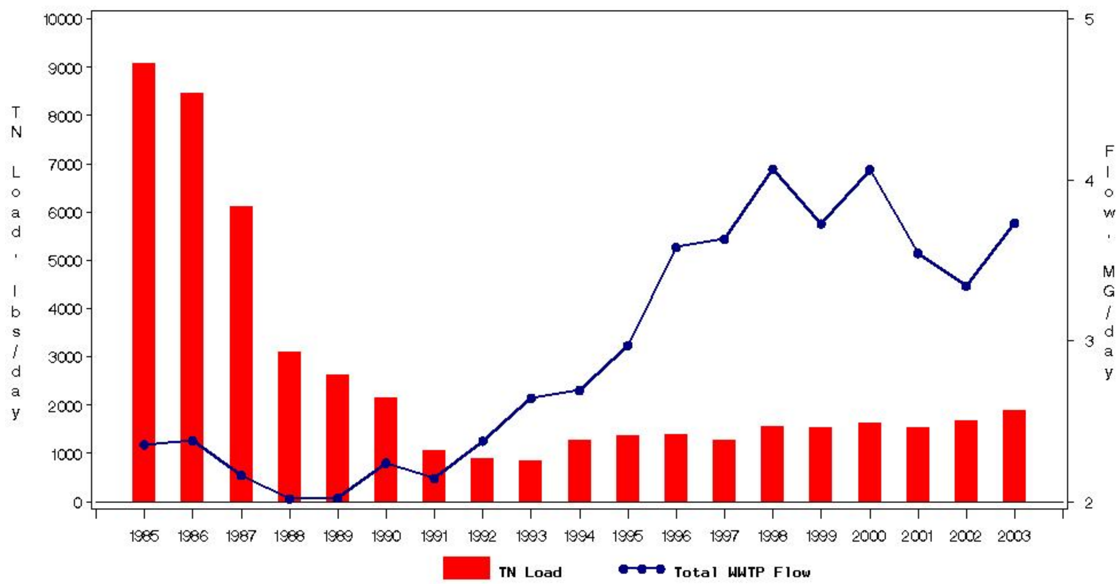
PATAPSCO Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



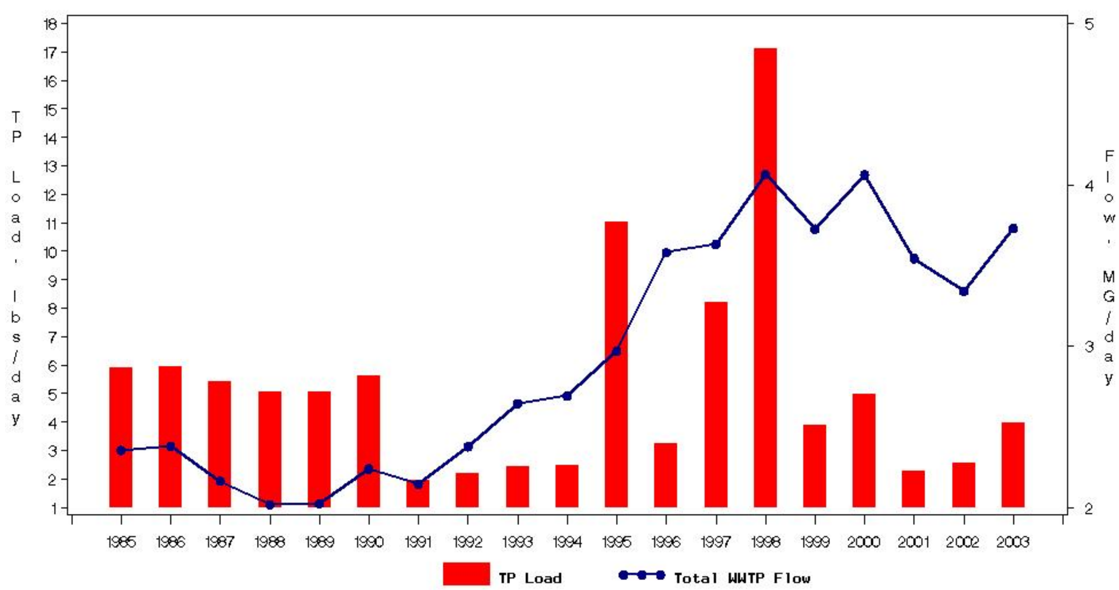
PATAPSCO Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow



W R GRACE Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow



W R GRACE Wastewater Treatment Plant: Patapsco—Back Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow

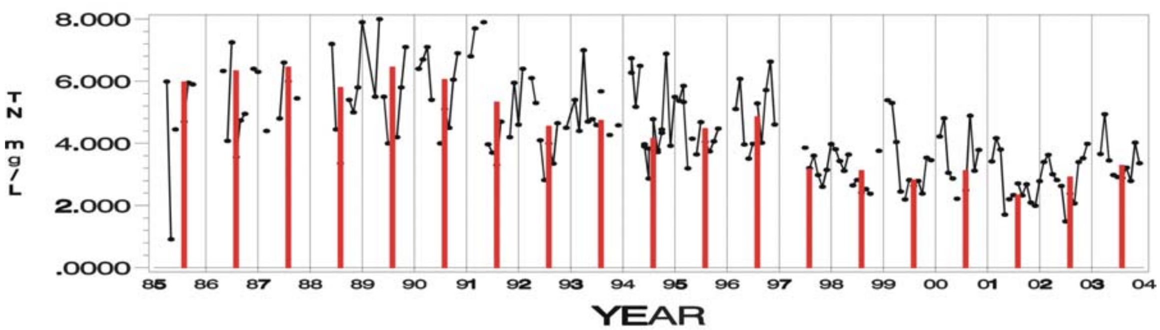


Appendix B – Measured Water Quality Concentrations for the Patapsco/Back Basin

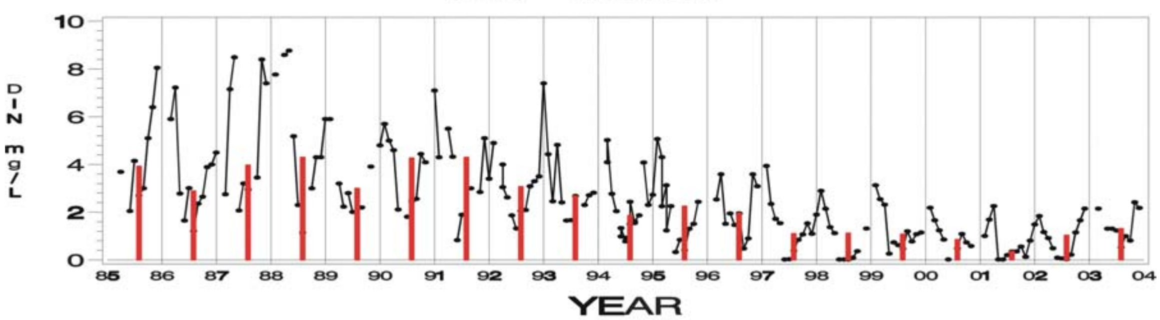
Water quality concentrations based on measured concentration data taken at long-term stations are graphed as follows. Mean concentration for the surface and above pycnocline data are shown for each sampling date as black dots. Annual median of those values is shown as red bar.

Note that parameter values tend to fluctuate highly from year to year, and much of this fluctuation can be attributed to flow conditions. For example, in high flow years (wet years), nutrient levels are higher than in dry years. Also, the timing of the spring freshet and other weather conditions can determine the strength and duration of the pycnocline, strongly affecting dissolved oxygen levels. Topography, hydrogeology, stream hydrology, how a basin is developed and management actions all affect the influence of weather conditions.

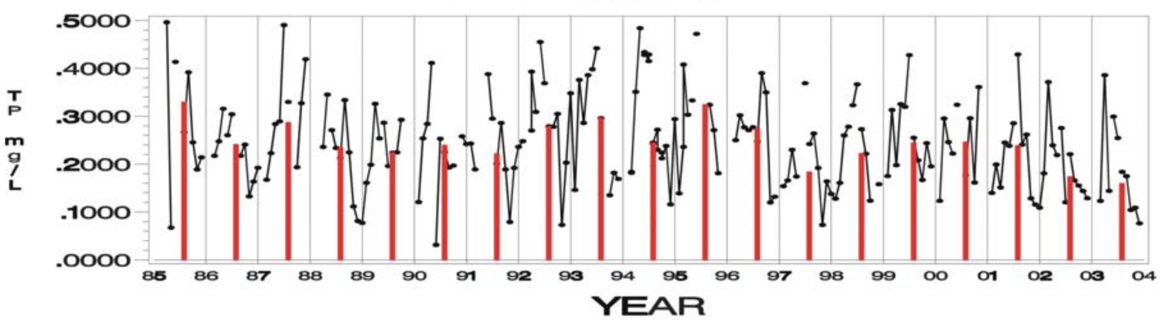
Total Nitrogen at WT4.1 (Back River), 1985–2003, layer=SAP
red bar = annual median



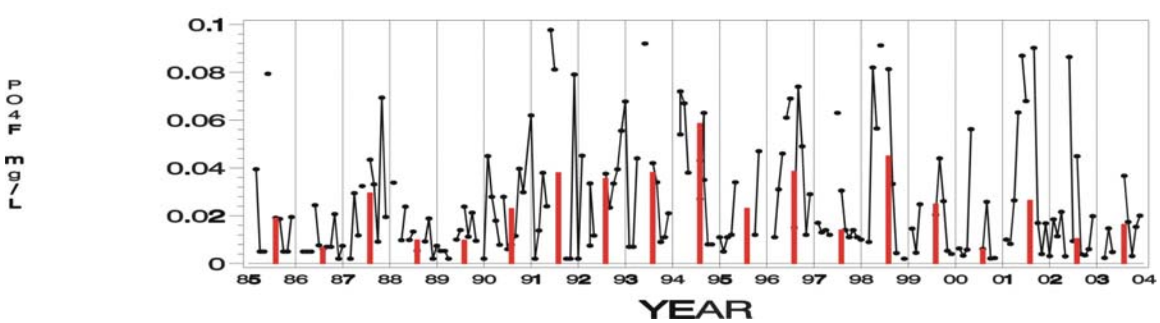
Dissolved Inorganic Nitrogen at WT4.1 (Back River), 1985–2003, layer=SAP
red bar = annual median

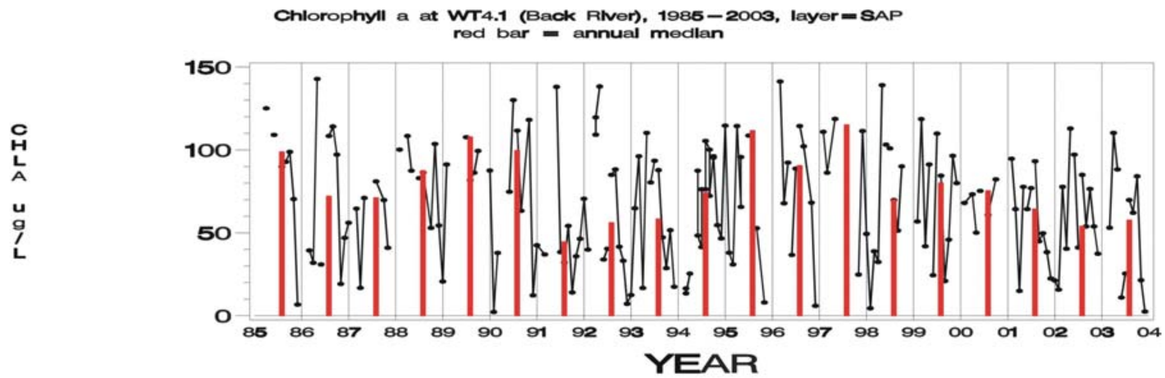


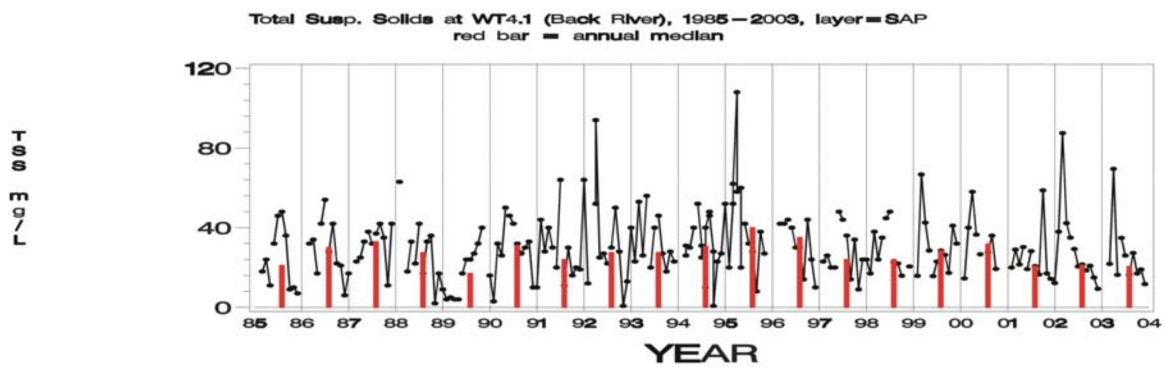
Total Phosphorus at WT4.1 (Back River), 1985–2003, layer=SAP
red bar = annual median

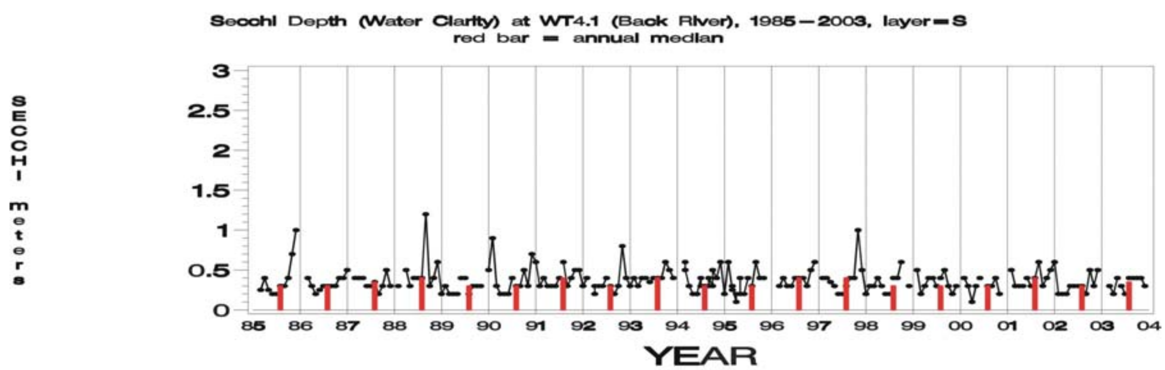


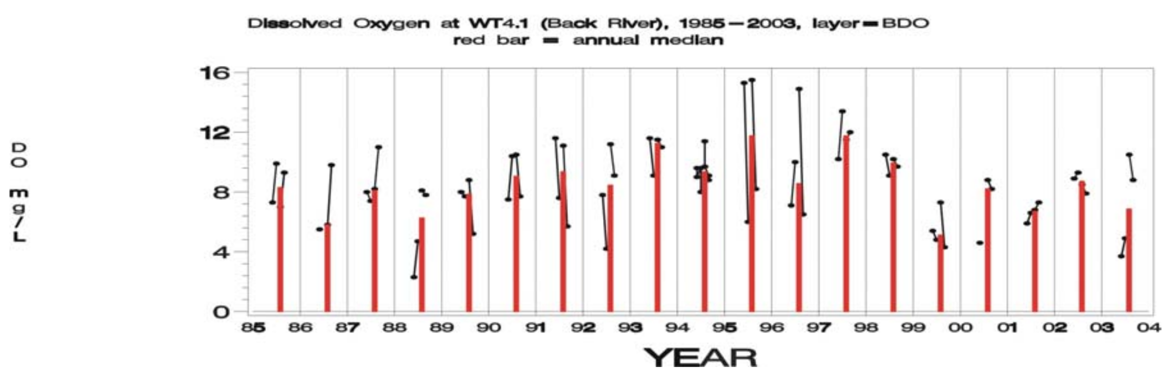
Orthophosphate at WT4.1 (Back River), 1985–2003, layer=SAP
red bar = annual median



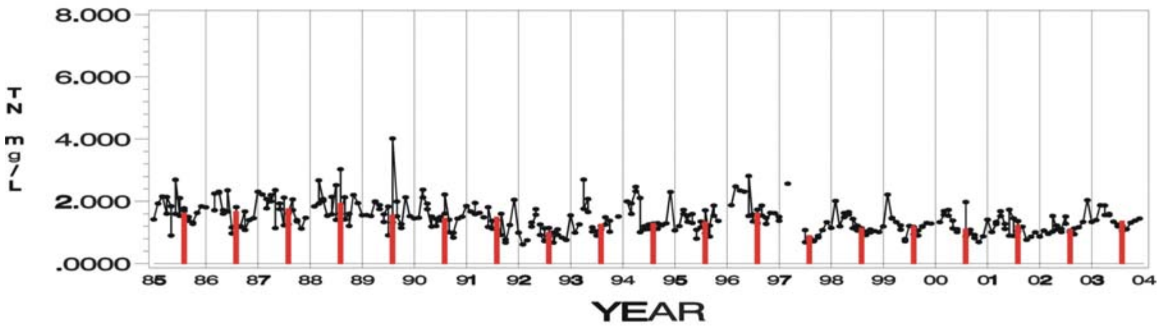

Chlorophyll a at WT4.1 (Back River), 1985 – 2003, layer = SAP
red bar = annual median
CHLA ug/L
YEAR


Total Susp. Solids at WT4.1 (Back River), 1985 – 2003, layer = SAP
red bar = annual median
TSS mg/L
YEAR

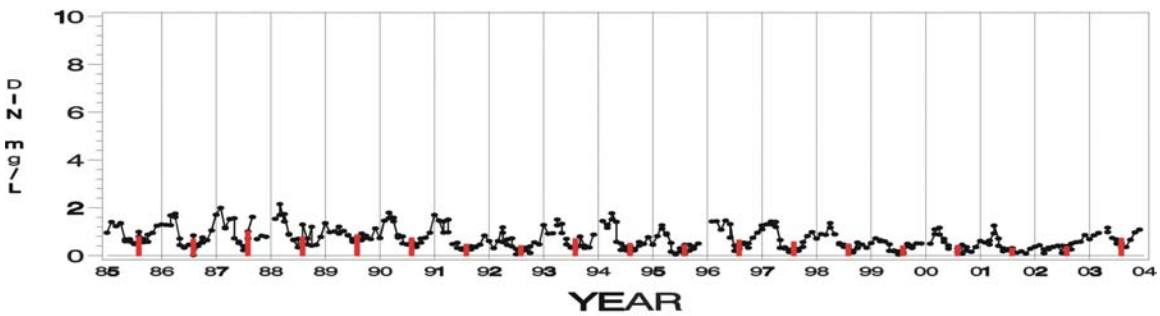

Secchi Depth (Water Clarity) at WT4.1 (Back River), 1985 – 2003, layer = S
red bar = annual median
SECCHI meters
YEAR


Dissolved Oxygen at WT4.1 (Back River), 1985 – 2003, layer = BDO
red bar = annual median
DO mg/L
YEAR

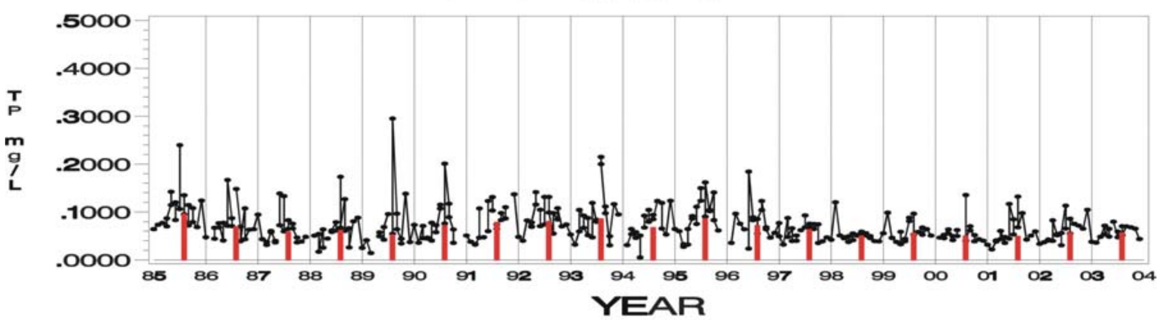
Total Nitrogen at WT5.1 (Patapsco River), 1985 – 2003, layer = SAP
red bar = annual median



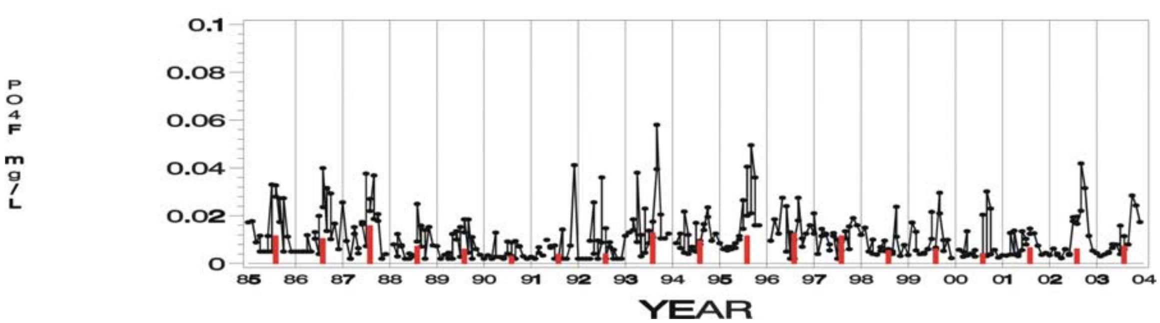
Dissolved Inorganic Nitrogen at WT5.1 (Patapsco River), 1985 – 2003, layer = SAP
red bar = annual median

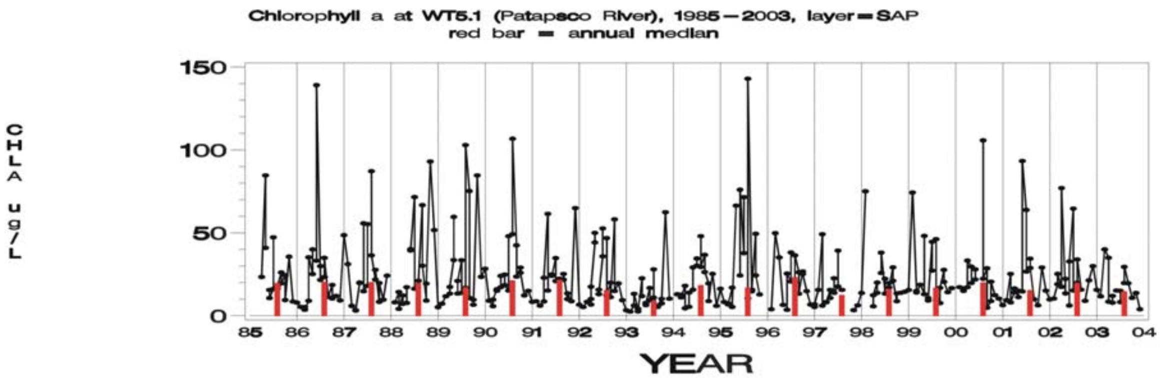


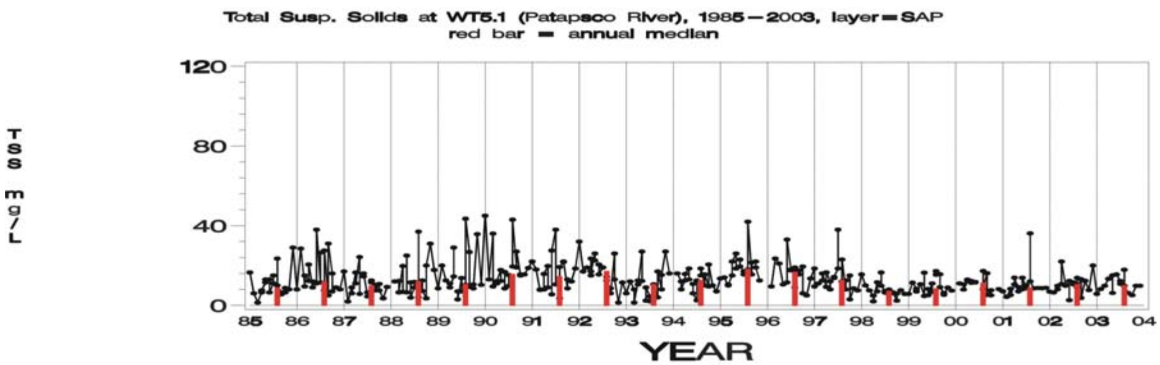
Total Phosphorus at WT5.1 (Patapsco River), 1985 – 2003, layer = SAP
red bar = annual median

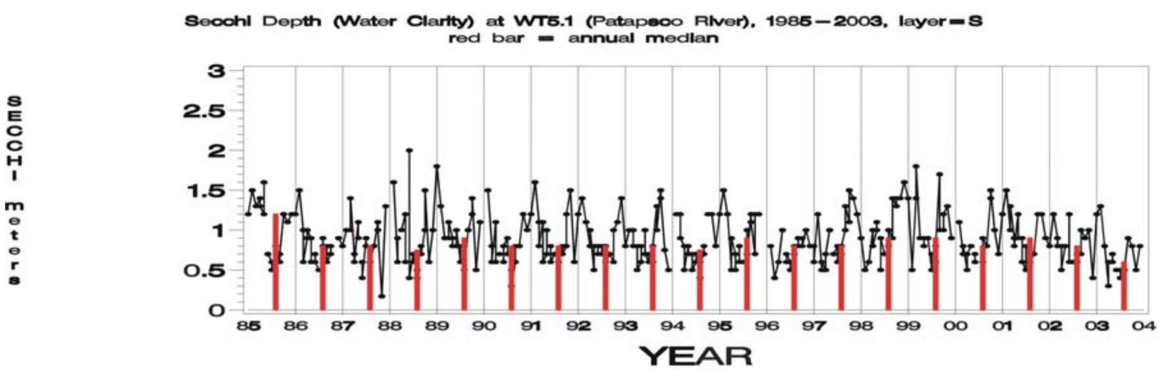


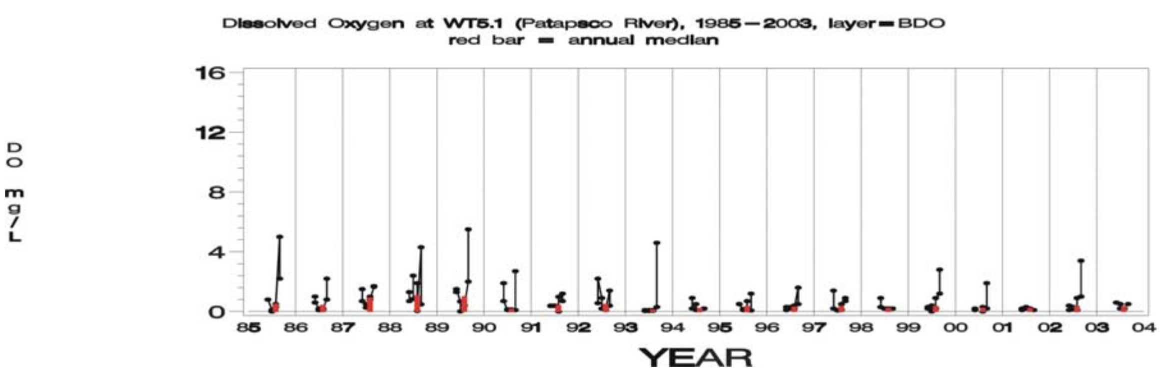
Orthophosphate at WT5.1 (Patapsco River), 1985 – 2003, layer = SAP
red bar = annual median




Chlorophyll a at WT5.1 (Patapsco River), 1985 – 2003, layer = SAP
red bar = annual median
CHLA ug/L
150
100
50
0
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Susp. Solids at WT5.1 (Patapsco River), 1985 – 2003, layer = SAP
red bar = annual median
TSS mg/L
120
80
40
0
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Secchi Depth (Water Clarity) at WT5.1 (Patapsco River), 1985 – 2003, layer = S
red bar = annual median
SECCHI meters
3
2.5
2
1.5
1
0.5
0
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Dissolved Oxygen at WT5.1 (Patapsco River), 1985 – 2003, layer = BDO
red bar = annual median
DO mg/L
16
12
8
4
0
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

Appendix C – Nutrient Limitation Text for the Patapsco/Back Basin

The nutrient limitation models were used to predict nutrient limitation for the stations in the Patapsco and the Back Rivers. Results are summarized for the most recent three-year period (2001-2003) by season: winter (December-February), spring (March-May), summer (July-September) and fall (October-November).

Back River (WT4.1) - On an annual basis, phytoplankton growth is nutrient saturated (light limited or no limitation) almost 70 percent, nitrogen limited more than 10 percent of the time and phosphorus limited almost 20 percent of the year. Winter growth is entirely nutrient saturated. In spring, growth is phosphorus limited 20 percent of the time and nitrogen limited 10 percent of the time. In summer, growth is nitrogen limited about 30 percent of the time and phosphorus limited 5 percent of the time. In fall, growth is phosphorus limited 45 percent of the time and otherwise is nutrient saturated. Total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus concentrations are all relatively poor at this station, but total nitrogen and dissolved inorganic nitrogen concentrations are improving (decreasing). The ratio of total nitrogen to total phosphorus and the ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorus ratios are both decreasing. The dissolved inorganic nitrogen to dissolved inorganic phosphorus ratio is relatively high in the fall which suggests that reductions in phosphorus may be the most effective means of controlling phytoplankton growth in that season. This ratio is low in summer (suggesting possible nitrogen limitation), but dissolved inorganic nitrogen concentration is still high. Continued reductions in nitrogen will further increase occurrences of nitrogen limitation in the summer. Reductions in both nutrients will be needed to limit growth in the winter and spring.

Patapsco River (WT5.1) – On an annual basis, phytoplankton growth is phosphorus limited almost 50 percent of the time and nitrogen limited 20 percent of the time. Winter growth is nutrient saturated (light limited or no limitation). In the spring, growth is phosphorus limited almost 75 percent of the time. In the summer, phytoplankton growth is nitrogen limited 50 percent of the time and phosphorus limited 50 percent of the time. In the fall, growth is phosphorus limited 50 percent of the time and nitrogen limited approximately 15 percent of the time. Total nitrogen, dissolved inorganic nitrogen, and total phosphorus concentrations are all relatively poor but are improving (decreasing); dissolved inorganic phosphorus concentration is fair. The ratio of dissolved inorganic nitrogen to dissolved inorganic phosphorus is decreasing; this ratio is relatively high in the winter, which suggests that reductions in phosphorus may be the most effective means of controlling phytoplankton growth in that season. This ratio is low in summer (suggesting possible nitrogen limitation), but dissolved inorganic nitrogen concentration is still high. Reductions in nitrogen will further increase occurrences of nitrogen limitation in the summer.

Appendix D – Glossary

algae bloom – high concentrations of phytoplankton (algae).

benthos – bottom-dwellers.

dinoflagellates – a type of flagellated single-celled phytoplankton; most are photosynthesizers but some are also heterotrophic.

epiphytic – growing on a plant. Epiphytic algae grow on the leaves and stems of bay grasses.

estuary – a semi-enclosed, tidal, coastal body where fresh water running off land mixes with salt water coming in from the ocean.

hypoxia – the condition of low dissolved oxygen (< 2 mg/L), which is detrimental to many living organisms.

nauplius – an early planktonic stage in the life of a crustacean.

nutrient – chemicals required for plant growth and reproduction; in this report the term nutrients generally refers to nitrogen and phosphorus.

plankton - organisms that are unable to swim strongly, and drift along with currents; many are microscopic

phytoplankton – plankton that are "plant-like" in that they are primarily or partially autotrophic (primary producers); many are tiny single-celled organisms; examples include diatoms and dinoflagellates.

tributary – a stream, creek or river that feeds into a larger body of water.

watershed – a basin that drains into a particular body of water.

zooplankton – plankton that tend to be "animal-like" in that they are primarily heterotrophic (e.g., they eat other organisms); examples include copepods and rotifers.

Appendix E – References

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